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Executive Summary

The shoreline within the study area continues to change through natural processes of erosion and accretion. This change is most evident following severe storms which occur during periods of high lake levels. However, these processes continue to change the shoreline even under lower water levels and the change is most often irreversible. As this change occurs, costly protection works can become necessary to protect homes and cottages constructed in close proximity to the shoreline. Even with protection works, some properties continue to experience recurring erosion damages. The shoreline hazards concern individual property owners, municipalities and the Province of Ontario. In order to address the issue, the Ministry of Natural Resources prepared guidelines to assist in the preparation of management plans for the shorelines of the Great Lakes. These guidelines introduce a prevention approach to reduce and/or eliminate future damages.

The Shoreline Management Plan forms the final step in a process which has involved research, mapping and public involvement. At the initial stage, it was necessary to gain a better understanding of the natural processes shaping the shoreline so that informed decisions could be made on the extent of the hazards and appropriate alternatives to address the hazard. Detailed topographic mapping was undertaken to assist in the calculation of long term recession rates and to clearly delineate the erosion hazard. In order to address the requirements of the Conservation Authority and the needs of the shoreline municipalities, property owners, and other government agencies, a public advisory committee was formed to obtain input from the various groups. The final Shoreline Management Plan is a reference document which incorporates the findings of the research and addresses the needs of the shoreline community. The SMP is meant to assist the shoreline municipalities, landowners and the public in making informed choices related to the shoreline resource.

The Province of Ontario has identified that development in hazardous areas is a matter of provincial interest and encourages a consistent approach to the issue through policies adopted under the Planning Act. The shoreline policy has been in development since 1989. During this development, the policy has undergone various format changes, changes in terminology and level of detail and flexibility. The basic principles and objectives of the shoreline policy have, however, remained consistent throughout the process with emphasis placed on prevention which is achieved by directing new development to locations outside of or to less hazardous portions of the shoreline.

The management strategy outlined in the SMP endeavours to address the Provincial Policy in the context of the existing development types, land uses and natural shoreline processes within the study area. The Shoreline Management Plan provides the criteria for the delineation of the flooding and erosion hazard areas, identifies the most hazardous lands, and appropriate development practices and standards for these areas.

The various forms of protection works which have been constructed over the years along the study area shoreline have not always been appropriate or effective in addressing the erosion hazard at all locations. Through the public advisory committee, it was identified that there was a need to provide property owners with useful technical information to introduce them to the concepts of how protection works are designed and what makes each structure type appropriate for different conditions. The supporting document entitled "Design Considerations for Shore Protection Structures" (Baird, 1992), outlines the various design conditions for protection works. The report also provides a range of management options as alternatives to the construction of costly structural protection.

The Shoreline Management Plan contains both general and site specific information on the shoreline resource, the hazards and the appropriate means of addressing the hazards. To encourage this prevention approach, the Shoreline Management Plan should receive wide distribution and be made

accessible to shoreline landowners, potential landowners, municipal representatives and staff, and the general public at municipal offices and public libraries.

Section 1 Introduction

1.0 Historical Background of Shoreline Management

Increasing pressure to develop within shoreline areas susceptible to flooding and erosion, particularly over the last forty years, has resulted in extensive and mounting property damages, risk to public safety and detrimental impacts to natural shore processes and ecosystems. In the early seventies, high lake levels in combination with major storm events, resulted in approximately \$30 million in flood and erosion damages and land losses along the shorelines of the lower Great Lakes. Between 1985 and 1987, a return to high lake levels in combination with a minimal number of storm events, resulted in a marked increase in flood and erosion damages to approximately \$60 million. Most damages having been sustained in the same areas which had previously experienced losses. (MNR Shoreline Policy (Draft), July 1992)

In response to the high lake level conditions during the mid-1980's, the Cabinet of the Ontario Government formed the Ontario Shoreline Management Advisory Committee (SMAC). The Committee was requested to hold public meetings and seek input on the issue of a long term approach to the management of shoreline areas, and report to the Ministers of Natural Resources and Municipal Affairs. Subsequent to public meetings held in 1986, the Committee made several recommendations including:

1. That the Ministry of Natural Resources (MNR) and the Ministry of Municipal Affairs (MMA) prepare a joint Policy Statement under Section 3 of the *Planning Act* to formally recognize Great Lakes shoreline management in municipal land use planning, and to reflect the Province's significant interest in the shoreline resource.
2. That the Ministry of Natural Resources prepare a Shoreline Management Plan to assist in consistent application of shoreline management policies. The Plan will identify regulatory flood and erosion criteria to define the extent of the hazard lands for regulatory purposes.
3. That the Conservation Authorities be identified as the agencies responsible for implementation of the shoreline policies of the Ministry of Natural Resources.
4. That the Conservation Authorities which border the Great Lakes be required to enact regulations under Section 28 of the *Conservation Authorities Act*. These regulations will allow the Authorities to prohibit or regulate construction of dwellings and structures and the placing of fill in shoreline flood and erosion hazard areas.

In December of 1986, the Honourable Vincent G. Kerrio, Minister of Natural Resources, announced the establishment of a long term provincial shoreline management program. The program was to be proactive, rather than reactive, emphasizing the implementation of prevention alternatives through shoreline management.

1.1 Conservation Authority Involvement and Responsibility

Following the recommendations of the Shoreline Management Advisory Committee, the Ministry of Natural Resources, in February of 1988, conferred full responsibility for reviewing and commenting on shoreline development planning applications to the conservation authorities bordering the Great Lakes. Extension of conservation authority official jurisdiction into the Great Lakes system, through orders-in-council, ensured their legal mandate and responsibility for municipal plan input and review. To assist and provide direction to the City of Sarnia and the Township of Plympton on management of their shoreline resources, the St. Clair Region Conservation Authority was directed to prepare a shoreline management plan.

In order to provide the necessary background information to support the preparation of a shoreline management plan, various studies were completed. The Lake Huron Shoreline Processes Study was undertaken in cooperation with three conservation authorities with jurisdiction over the southeastern shore of Lake Huron. The study, completed by F.J. Reinders and Associates Canada Limited in 1989, investigated the natural processes of bluff erosion and sand movement (littoral drift) occurring along the shoreline. Shoreline topographic mapping at a scale of 1:2000 was completed under the Canada/Ontario Flood Damage Reduction Program (FDRP) in 1990. This mapping was based on aerial photographs taken in April of 1988 and is available in a hard copy (paper) and digital format. The Lake Huron Shoreline Erosion Hazard Delineation Study, completed by Reinders and Geomatics International in 1991, compared historical shoreline information to determine long term recession rates for the study area.

To assist in the development of the SMP, the Conservation Authority formed a project committee in 1991 which came to be known as the Shoreline Management Advisory Committee. This Committee had membership composed of Conservation Authority directors, municipal and Conservation Authority staff, and shoreline residents and was established to direct and provide input into the SMP.

1.2 Outline of Shoreline Management Plan (SMP)

The principal goals of a SMP are to minimize the risks to life and property damage from flooding, erosion and associated hazards along the shoreline, and to ensure that shoreline development adequately addresses flooding and erosion hazards through a combination of public and private management and development alternatives. In order to develop a comprehensive, coordinated approach to shoreline management, the SMP must give direct recognition to local shoreline processes and characteristics and associated flood and erosion risks. In addition, the SMP is intended to act as a reference document through which informed land use planning decisions can be made. To achieve these objectives, the SMP will utilize mapping to identify areas subject to flooding, erosion, storm damage and bluff instability and recommend appropriate setbacks for new development. In addition, the SMP will address existing development by providing management options and, direction and guidance on protection works alternatives.

1.2.1 Ministry of Natural Resources (MNR) Guidelines

To assist in the development of shoreline management plans in Ontario and provide a common planning framework around the Great Lakes, the MNR prepared the document entitled Guidelines for Developing Great Lakes Shoreline Management Plans (1987). The Guidelines outline six (6) components including:

Prevention

- The identification and implementation of development controls to prevent flood and erosion threats to new development. Existing implementation mechanisms possible through the *Planning Act* and the *Conservation Authorities Act*.

Protection

- The identification of areas which may require capital works to prevent threats to existing development.

Emergency Response

- The initial responsibility for reacting to emergencies is at the local level. Municipalities are encouraged to prepare or amend existing emergency plans to provide for emergency action related to shoreline situations.

Public Information

- The development of a public information program emphasizing the dissemination of information and education of the general public to aid in the shoreline management planning process.

Environment

- The preliminary assessment of potential short and long term effects to terrestrial and aquatic ecosystems.

Monitoring

- The identification of any changes over time to local conditions which may adversely effect shoreline management programs and the identification of any necessary modifications to the shoreline management plan.

1.2.2 Addressing Local Issues

The issues specific to the study area shoreline were identified with the assistance of the Shoreline Management Advisory Committee and reflect local conditions and concerns as follows:

Shoreline Erosion/Wave Damage

The long term recession of the bluffs and banks threatens existing development and may limit future development along the study area shoreline. The erosion of the sand beaches which front the backshore bluffs reduces the recreational value of the shoreline and the ability of the beaches to protect the backshore area. Severe storms often occurring during periods of high lake levels, have resulted in wave impact damage to public and private shoreline protection works and property. Efforts to protect the backshore from erosion and assist in beach development have met with limited success and have often created additional problems such as:

- adverse downdrift impacts, both local and regional due to the reduction in the supply of sand to the shoreline.
- nearshore lakebottom erosion accelerated by wave reflection of vertical seawalls.
- safety hazards, poor aesthetics and reduced utility of the shoreline due to exposed steel, broken concrete debris on beaches and groyne construction across beaches.

The extent and recurring nature of the problem has been demonstrated by long term recession of the shoreline and damage to protection works and property during historical storm events during November 1913, June 1953, March 1973, November 1983 and November 1986. Shoreline erosion protection works which are properly designed and constructed to address long term bluff recession and wave damage are expensive and generally not within the financial resources of private landowners. Generally, the protection works constructed within the study area represent relatively low cost alternatives which provide limited protection over a short design life.

Runoff/Drainage (Surface and Groundwater)

Runoff and groundwater may be contributing factors to bluff erosion over a significant portion of the eroding bluffs within the study area. Surface runoff causes erosion of material from unvegetated bluff faces. Groundwater flow and seepage through the bluff face reduces soil shear strength and contributes to bluff slumping and long term recession. Agricultural and municipal drains have caused the formation of gullies. Bluff regrading, revegetation and extensive drainage systems are expensive measures particularly in high bluff areas where seepage areas are located well down the bank. However, low cost measures to address surface runoff and shallow groundwater seepage have been used extensively along the study area.

Public Access to and Recreational Use of Shoreline

Public access to the shoreline within the study area is limited to six public parks and several municipal road allowances running parallel to the shoreline or intersecting the shoreline. Information on the location and characteristics of these access points should be available to all municipal residents. In addition, these existing areas should be maintained in public ownership and upgraded where necessary for the benefit of the general public.

1.2.3 Shoreline Management Plan Components

The requirements for shoreline management plans outlined by the MNR guidelines and the issues of local concern are similar and can be addressed as follows:

1. Prevention of damage to future development through the use of setbacks and guidelines which can be incorporated into existing municipal planning documents. Under Section 3, the Shoreline Management Strategy addresses new development (multi-lot subdivision, redevelopment of existing lots, reconstruction of existing dwellings). Development guidelines incorporate setbacks to ensure that development does not become prematurely at risk due to shoreline erosion. Setbacks are based on local conditions associated within long term recession rates and, shoreline characteristics and processes. Under Section 4, Community Prescriptions describe shoreline characteristics and provide detailed mapping showing the extent of erosion hazard areas.
2. Protection of existing development recognizing the high cost of engineered structures, potential impacts on adjacent properties and natural shoreline processes. Section 2 provides a description of the natural shoreline processes and discusses the erosion hazards. General recommendations are provided on shoreline erosion protection works. The supporting document "Design Considerations for Shore Protection Structures (1992)" provides a more detailed discussion with an outline of management alternatives and protection works design conditions.
3. Emergency response to erosion events causing significant damage to shoreline properties and protection works. Under Section 5, the roles and responsibilities of the various agencies regarding emergency planning are outlined.
4. Public information through input from the Shoreline Management Advisory Committee, public presentation and distribution of the SMP. Section 6 of the SMP outlines the public involvement undertaken as part of the planning process.
5. Environmental issues related to the potential impacts of shoreline erosion protection works and bluff stabilization works on aquatic ecosystems. The supporting document "Design Considerations for Shore Protection Structures (1992)" describes existing environmental legislation and outlines approval requirements.
6. Monitoring of the shoreline can assist in the recognition of changes to the shoreline and verification of the extent of the erosion hazards. Section 5 outlines existing monitoring programs and provides recommendations on other issues and appropriate monitoring techniques.

1.2.4 Overall Objectives of the Shoreline Management Plan

1. Identify and provide technical documentation on the shoreline hazards.
2. Delineate the shoreline hazard area and provide guidelines which direct new development outside hazard areas.
3. Provide an outline of management alternatives and protection works design considerations.
4. To recognize the continuing economic development of the shoreline area and provide technical information which will assist in effective planning thereby maintaining the high quality of life and state of the shoreline resources in the region.

1.2.5 Implementation of the Shoreline Management Plan

The method of SMP implementation and level of support is to be the decision of the municipalities that share lakeshore frontage, namely the City of Sarnia and the Township of Plympton. However, it is recommended that the SMP be considered for adoption by the shoreline municipalities and the County of Lambton Department of Planning and Development. Reference to the SMP by planning staff should provide for consistent incorporation of SMP principles into the planning documents (i.e. zoning by-laws, secondary plans and official plans) of shoreline municipalities.

Review of the SMP by the general public, through various means, is encouraged and should be achieved with the support of all participants involved in preparation of the SMP.

Section 2 Understanding the Lake Huron Shoreline

2.0 Study Area Description

The study area contains approximately 32 kilometres of the Lake Huron shoreline from the Bluewater Bridge in Point Edward northeast to the Plympton Township townline with Bosanquet Township at Hillsboro Beach (Figure 1). The study area includes the shorelines of the City of Sarnia and the Township of Plympton within the County of Lambton. The lands immediately north of the Bluewater Bridge to the Lambton Water Treatment Plant are located within the Village of Point Edward. These lands are hardened against erosion by engineered protection works. The property contains a municipal park and is designated for passive open space uses in the land use planning documents. There are no anticipated development issues associated with these lands over the long term and therefore they are not addressed in the SMP.

The geomorphic interface between the shorelines of the St. Clair River and Lake Huron is located in the vicinity of the Bluewater Bridge. In this area the principal influence over littoral processes changes from wave action to hydraulic flows. On the lake, the sediments (sand) are moved along the shoreline by currents created by the action of waves. Once entering the river these same sediments are moved by currents created by the flow of water.

The shoreline is a linear corridor where connected green spaces can be enhanced by supporting the creation and maintenance of various parks and trail systems. There are several existing public parks in the study area including Canatara Park, Huron View Park and Wildwood Park in the City of Sarnia and C.J. McEwen Conservation Area and Highland Glen Conservation Area in Plympton Township. In addition, there are several local parks located where municipal road allowances meet the shoreline. Baxter Park, located at the north end of Colborne Road, is an example of this type of park in Sarnia. In Plympton Township, the Village of Errol has local parks located at the north ends of Main Street and Frances Street.

Within the City of Sarnia there are three linear trail systems including the Point Edward Waterfront Park and Trail, the Old Lakeshore Road in Brights Grove and the Howard Watson Nature Trail. The Old Lakeshore Road contains approximately 4.5 kilometres of publicly owned road allowance stretching from Telfer Road to Cow Creek. The trail crosses the outlet of the Perch Creek (Cull Drain) over the Old Lakeshore Road steel truss bridge in Lot 24 which has been closed to vehicle traffic. The trail alternates between paved roadway and paved pathway. In two areas the trail has been abandoned and the lands are maintained by the adjacent private property owners.

The Howard Watson Nature Trail is located within the abandoned C.N. Railway right-of-way and extends approximately 12 kilometres from Wiltshire Park to Mandamin Road. The trail is crossed by several municipal roads and two watercourses. These features provide linkages to the shoreline.

2.1 Natural Processes Shaping the Shoreline

The study area shoreline can be classified into two general reaches. To the northeast of Brights Grove, the shoreline typically consists of cohesive bluffs of low to moderate height fronted by narrow beaches, and in places, extensive shoreline protection works. To the southwest of Brights Grove, the shoreline typically consists of vegetated dunes fronted by beaches of varying widths. The entire shoreline within this latter reach is protected by an extensive series of groynes, seawalls and revetments. Erosion of the shoreline varies from limited to severe within both reaches, and is dependent on a number of factors, including the nearshore wave climate, the composition of the shoreline and nearshore lake bottom, and the extent and quality of existing shoreline protection works.

Erosion of the bluffs to the northeast of Brights Grove, as well as erosion of the nearshore lake bottom at locations throughout the study area, supplies sediment (clay, silt, sand and gravel) to the shore zone. These materials are transported by wave action and currents. The finer sediments (clay and silt) are carried in suspension and tend to deposit offshore in deep water, while the coarser sediments (sand and gravel) are transported along the shoreline and form beaches and bars. The extent of these features is dependent on a number of factors, including the supply of sand and gravel to a particular location and the nearshore wave climate and water depths.

Due to the wave climate and shoreline orientation in the study area, the net transport of sand is from northeast to southwest. In addition, the rate of sand transport along the shoreline is limited by the supply of sand from updrift erosion. The beaches represent an equilibrium condition between the nearshore wave climate and this limited supply of sand. In addition, the beaches are dynamic in nature, and respond to varying water levels and wave conditions through cross-shore transport and beach profile adjustment. The dynamic nature of the beaches is an important consideration in the design of shoreline erosion protection works.

The construction of shoreline protection works will reduce the supply of sand to the downdrift shoreline through reduced erosion rates, and may interfere with the natural longshore transport processes. As such, the continuing construction of shoreline protection works may have a significant impact on the downdrift shoreline. This is an important consideration in the management of the study area shoreline.

2.2 Shoreline Erosion

Although wave action at the shoreline is the dominant force in the evolution of the shoreline, the response of the shoreline to wave action depends on the composition of the soil at the shoreline and on the nearshore lake bottom. In fact, the erosion of the shoreline is preceded by, and controlled by, a slow but continuing erosion of the nearshore lake bottom. The presence of an erosion-resistant material on the nearshore lake bottom (in depths less than approximately 2 metres) and at the base of the bluff results in a relatively stable shoreline, while the presence of an erodible material on the nearshore lake bottom and at the base of the bluff results in an eroding shoreline (and nearshore lake bottom).

Only limited data describing the composition of the nearshore lake bottom is available in this area (for example, Rukavina, 1988). However, limited diver observations collected in the summer of 1991 indicate good correlation between the composition of the nearshore lake bottom and the shoreline erosion. Specifically, in the area known as Wees Beach (Colborne Road) in Sarnia, the lake bottom is completely covered by a "lag deposit" of gravel and cobbles. This material is the byproduct of erosion (over many years) of a stoney till (Rannoch till) which comprises the lakebed in this area. Historically, wave action has eroded the surrounding clay matrix, leaving the gravel and cobbles as a protective layer. This layer effectively stabilizes the lake bottom, and limits erosion of the shoreline in these areas. On the other hand, in the vicinity of Rainbow Cove (Huron Shores Drive) and Brights Grove, in Sarnia, the lakebed consists of a relatively soft till (St. Joseph till); this material contains very little gravel and cobbles, and is readily eroded by wave action. As a result, the nearshore area has become progressively deeper over time, resulting in severe shoreline erosion and considerable damage to existing shoreline protection works in this area.

Clearly, the design of shore protection structures must consider the erosion of the nearshore lake bottom. Specifically, erosion of the lakebed in front of a structure may result in undermining of the structure, leading to damage and perhaps failure of the structure. In addition, this process will result in deeper water in front of the structure, thus allowing larger waves to attack the structure in the future. Both of these factors must be considered in the design of shoreline erosion protection works.

2.3 Protection Works

Along the shoreline of the study area it will become increasingly necessary to balance the desire to maintain (and enhance if possible) the existing sand beaches along the shoreline with the increasing pressure for erosion protection works. In order to maintain the beaches, the natural shoreline processes must continue, including the erosion of the bluffs which supply sand to the shoreline, the longshore transport of sand to the southwest, and the deposition of sand in the area of Canatara Park. Wherever possible, the use of development setbacks, the relocation of existing buildings, and the consolidation of adjacent properties should be utilized rather than the construction of shore protection structures. Eliminating shore protection structures allows the bluffs to continue to erode and provides sand to the shoreline.

Long term annual rates of bluff recession vary considerably from zero to more than 0.7 metres per year. Short term recession rates can be much higher than the historical average due to high lake levels and severe storms. The process of recession in the bluff areas is continual and the loss of land is permanent. Bluff areas experiencing recession typically have little vegetative cover on the slope face, are fronted by narrow beach deposits and have an eroding nearshore lake bottom.

Waves striking man-made structures along the shoreline can result in considerable damage. Unlike flood damage, where damages result from inundation, wave damages are caused by the force of a wave striking a structure. Water level fluctuations have a considerable influence on shore erosion, primarily by exposing different parts of the shore to wave action. When lake levels are high, the beach is inundated and the area of attack of breaking waves moves inland. The effectiveness of the beach as a defence is reduced and erosion increases rapidly. At low water levels, a wider beach is exposed and waves break further away from the shore.

More detailed discussions of shoreline processes, shoreline erosion, and design considerations and alternatives for shore protection structures (specifically those intended to prevent long-term erosion and stabilize the shoreline) are presented in the supporting document entitled "Design Considerations for Shore Protection Structures" (Baird, 1992). With respect to structures intended to prevent wave runup damage during high lake level conditions, the interested reader is referred to previous publications by MNR (1986) and USACOE (1977, 1981).

The following twelve (12) recommendations are summarized from the supporting document entitled "Design Considerations for Shore Protection Structures" (Baird, 1992). Where the construction, reconstruction or upgrading of protection works is meant to support the development or redevelopment of adjacent lands, these structures should be designed by a qualified professional engineer with experience on the Great Lakes.

1. In areas subject to moderate to severe long term erosion (average recession rate greater than 0.3 metres per year), and/or where the potential for property damage is great (for example, Brights Grove), an engineered sloping rubblemound revetment is the recommended erosion protection structure. The design of any revetment should consider the long term erosion (or downcutting) of the nearshore lake bottom.
2. In many locations within the study area, groynes have been used successfully to widen recreational beaches and provide protection to the backshore bluff or bank under normal lake level conditions. However, during storm events occurring during periods of high lake levels, waves can temporarily overrun these beaches and directly attack the backshore bluff materials. In addition, beach erosion can occur under these conditions leaving the shoreline vulnerable to damages. Groynes may not provide full protection to the shoreline during extreme conditions.

3. In areas subject to minor long term erosion (average recession rate less than 0.3m/yr), a rubblemound revetment is the recommended approach, but groynes may be an acceptable alternative. However, construction associated with groynes requires the permission of the Ministry of Natural Resources and due to potential negative impacts on neighboring properties approvals are generally limited to the repair and/or replacement of existing groynes. Where new groyne construction is approved, these groynes should be prefilled with suitable beach sand (clean sand and gravel, median grain size, $D_{50} > 0.3$ mm) in order to minimize downdrift impacts. It should be noted that groynes may not provide full protection to the shoreline during extreme conditions (severe storms at high lake levels).
4. Offshore breakwaters containing imported beach fill are an alternative that can provide significant recreational benefits as well as effective erosion protection. This type of approach is relatively expensive, but should be considered by communities such as Brights Grove, where other goals exist besides erosion protection (such as enhanced public access, improved recreational facilities, protection of municipal facilities, etc.). The primary design issue associated with this type of project is the potential adverse impacts on the longshore transport of sand.
5. Where erosion protection is required to stabilize the shoreline against long term recession, reflective vertical seawalls, such as steel sheet pile walls, are not recommended. Retaining walls may be used for wave uprush protection, as discussed below.
6. Any number of structures may be considered for wave damage protection. These include revetments and groynes, as discussed above, and retaining walls of various construction (gabion baskets, steel sheet piling, concrete). Retaining walls should be constructed behind the active beach zone (i.e. not exposed to direct wave action, and only exposed to wave runup during extreme conditions (storms at high lake levels)) in order to minimize impacts on the beach and shoreline processes. In general, these types of structures should only be considered where a relatively wide beach exists. In addition, the design of these structures should recognize the dynamic nature of the beach over the full range of lake level conditions.
7. With respect to improving the performance of existing shore protection structures, beach nourishment should be considered in areas where there are groynes which are in good repair but are not full with sand. Consideration should also be given to replacing reflective vertical seawalls with sloping rubblemound revetments. At a minimum, existing seawalls should be provided with toe protection to prevent or reduce the scour by waves at the base of the wall. In addition, splash pads should be provided to prevent the removal of material from behind the wall by overtopping waves.
8. Shoreline erosion protection works will generally require regular maintenance to ensure continued performance levels and structural stability.
9. From a theoretical perspective, regional beach nourishment would be a desirable protection alternative with respect to maintaining/enhancing the natural shoreline processes. A nourishment scheme would involve placing in the order of 10,000 to 20,000 cubic metres of sand on the shoreline each year, and could involve "recycling" sand from Canatara Park. It is recommended that this approach be investigated in more detail with respect to its economic and technical feasibility, as well as implementation issues such as permitting.
10. Bluff stabilization works have been undertaken at some locations within the study area through the regrading and/or terracing of the shoreline bank to achieve a more gradual and stable slope. Although limited research has been done along the Great Lakes on effective

means of slope stabilization, it is generally accepted that bank regrading requires site specific investigation and should attempt to achieve a 3 horizontal to 1 vertical slope, use erosion protection works constructed along the toe of the bank outside of the active beach zone, and utilize drainage improvements to contain and direct surface water. Care is required to ensure that the sides of the regraded area are gradually shaped to provide a transition slope from neighboring slopes. Due to the scale of the work required, the property needs substantial frontage with a low erosion rate to be considered feasible. Special attention to the subsurface drainage is critical as groundwater seepage zones may be interrupted by the work. The timing of establishing the vegetative cover is also crucial to the success of the project.

11. Drainage improvements both for surface and subsurface will enhance bank stability, especially where groundwater seepage is a concern. When water is artificially collected, the outlet needs to be taken to an appropriate location where erosion protection is provided and gully development is prevented. Subsurface drainage improvements should de-water the bluff and help to reduce bank movement during extreme precipitation and high soil moisture conditions. "French drains" have been used effectively along the top of the bluffs as a means to intercept both surface runoff and shallow groundwater seepage. These drains consist of perforated drainage pipe laid at the bottom of an excavated trench of varying depth (depending on site conditions) and backfilled to the surface with clear stone. The water collected by this system is then carried in a non-perforated pipe down the bluff face to beach level or to an appropriate storm drainage system.
12. Vegetative growth on banks is encouraged to promote stabilization and reduce the effects of rain impact and surface water runoff erosion. Grasses and shrubs are best suited for bluff slopes where bank movement is likely to continue due to erosion of the toe of the bluff by wave action. Vegetation acts to remove moisture from the bluff through evapotranspiration and root systems act to bind soil particles. Groundwater seepage areas along the bluff face can be planted using moisture tolerant species. The publication "The Role of Vegetation in Shoreline Management" (Environment Canada and United States Army Corps of Engineers), is an excellent reference for more information.

2.4 Implementation of Protection Works Recommendations

- a) A co-ordinated approach for erosion protection (by community or subdivision) is recommended. The combined resources of several property owners reduces the overall cost of the project and protection works of extended length and similar construction improve structure performance. In many areas, a community approach is the only effective means of addressing the erosion hazard.
- b) Prior to design, the ownership of the land on which the structure is to be built should be clearly established by the landowner.
- c) The design of structures located above the 100 year flood level that are intended to provide protection from wave runup and storm damage should follow guidance presented in MNR (1986) and/or USACOE (1978, 1981). The design of these structures should recognize the dynamic nature of the beach which fronts the structure.
- d) The design of structures which extend below the 100 year flood level and/or that are intended to stabilize the shoreline against continuing erosion should be prepared by a professional engineer with experience and qualifications in coastal engineering. The design of these structures must consider the erosion of the nearshore lake bottom, as well as the dynamic nature of the beach.

- e) Any application to construct shoreline erosion protection works should be accompanied by a detailed description of the site and proposed work, and an impact assessment which demonstrates the following points:
 - the proposed works will not increase the long term shoreline erosion rate at adjacent properties,
 - the proposed works will not adversely affect longshore sand transport rates,
 - the proposed works will not adversely affect adjacent structures and property, and
 - the proposed works will not adversely affect the shoreline ecosystem.
- f) Any application for shoreline erosion protection works, including the impact assessment, should be circulated to all property owners within 150 metres of the property boundaries in question to solicit their written comments prior to the responding to the applicant.
- g) Quality control during construction is an essential component of a successful project, and suitable construction observation services should be provided.
- h) Monitoring of completed projects should be completed annually, and following severe storms, such that potential problems can be identified and any required maintenance can be completed before excessive and unrepairable damage occurs.

Section 3 Shoreline Management Strategy

The prevention component of the Shoreline Management Plan will be outlined through a shoreline management strategy for the study area. The strategy will be directed by the prevention approach articulated through the Province of Ontario's Natural Hazards Management Program and Policies. However, the implementation of provincial goals and objectives within the study area must be balanced against local shoreline conditions. The shoreline development policy will provide direction to the City of Sarnia and the Township of Plympton on shoreline flood and erosion issues as they relate to land use planning and development.

3.0 Natural Hazards Management

Within Ontario, directing development to areas outside of flood, erosion and dynamic beach susceptible lands or to the less hazardous portions of these areas, is the preferred approach. In doing so, municipalities reduce the need for costly protection and emergency response measures. At the same time, this ensures that existing natural hazards are not aggravated or that new natural hazards or environmental impacts are not created on adjacent lands. In many municipalities, this is achieved by the acquisition of highly sensitive and natural hazards vulnerable areas, or by returning these areas to a natural state. In doing so, this establishes a network of undeveloped areas suitable for inclusion in the municipality's greenspace or parks system, thereby enhancing the quality of life. The basic objectives of natural hazards management are:

- minimizing risks to life, property damage, social disruption and adverse environmental impacts; and,
- ensuring a coordinated and environmentally sound approach to the wise use and management of lands susceptible to natural hazards in a manner integrated with land use planning.

The following eight (8) principles are applied to achieve program objectives:

NATURAL HAZARD MANAGEMENT PROGRAM PRINCIPLES

1. Proper natural hazards management requires the simultaneous recognition and addressing of natural hazards and ecosystem integrity in a manner integrated with land use planning;
2. Effective natural hazards management can only occur on a comprehensive shoreline (littoral cell or shoreline sediment compartment) or watershed basis with due consideration given to physical processes, effects of adjacent development and associated environmental impacts;
3. Local conditions (geophysical, hydrological, environmental, economic and social characteristics) vary from one stretch of shoreline to another and one watershed to another, and accordingly, should be taken into account in the planning and managing of areas susceptible to natural hazards;
4. The degree of risk (threat to life and property damage) can vary from shoreline to shoreline and watershed to watershed; the potential for development to safely occur may exist in some locations and may be too hazardous in other locations;
5. Development susceptible to natural hazards or which will cause or aggravate natural hazards threats to existing and/or approved uses and areas or which will cause adverse environmental impacts should not be permitted to occur unless the natural hazards and/or environmental impacts have been addressed;

6. Where development may be permitted, the development be directed to the least hazardous portions of the areas of natural hazards to minimize the potential risks to life and property damages and to reduce costs associated with addressing the hazards and emergency response;
7. Where development may be permitted within the natural hazards susceptible areas such developments will be undertaken in an environmentally sound manner in recognition of other resource values; and
8. Natural hazards management and land use planning are distinct yet related activities that require overall coordination on the part of municipalities and other government agencies.

3.1 Development of Provincial Shoreline Policy

In response to flood and erosion damages experienced around the Great Lakes during high lake level conditions of the mid-1980's and following the recommendations of the Ontario Shoreline Management Review Committee in 1986, the Ministry of Natural Resources (MNR) in 1987, formally identified that shoreline development was a matter of "provincial interest" and began preparation of a policy statement under section 3 of the *Planning Act*.

The policy statement was completed and adopted by the Ministry's Policy Committee headed by the Assistant Deputy Minister, in May of 1990 as an internal ministry policy. Ministry approval was reaffirmed in June of 1992 and September of 1993. Prior to review by the Ontario Cabinet and release for public review and consultation in 1991, the Ontario Government began a process to reform the planning system in the province.

After two years of public consultation, the Sewell Commission on Planning and Development Reform in Ontario submitted its final report on planning reform in June 1993. In response to the recommendations of the Sewell Commission, the Ministry of Municipal Affairs in May of 1994, released a package of legislation, policy statements and administrative changes to the planning system in Ontario.

The Comprehensive Set of Policy Statements were released on May 18, 1994 after receiving approval from the Cabinet of the Ontario Government. These policies were issued under section 3 of the *Planning Act* and came into effect on March 28, 1995 as part of Bill 163 which included amendments to the *Planning Act* as well as several other pieces of legislation. These policies replaced several existing policy statements and introduced new policies on natural heritage, environmental protection and hazards, agriculture and conservation. Policies to address development adjacent the shorelines of the Great Lakes were included within Section A - Natural Heritage, Environmental Protection and Hazard Policies.

The provincial policies were again revised with changes to the Planning Act under Bill 20 in the spring of 1996. The Provincial Policy Statement maintained the overall intent of the previous policies regarding public health and safety. Policies to address development adjacent the shorelines of the Great Lakes are contained under Section 3.

3.2 Provincial Policy Outline

Relevant excerpts from the Provincial Policy Statement (May 22, 1996) related to the Great Lakes shorelines are reproduced and described in greater details with reference to the shoreline of the study area.

II. Principles

Ontario's long term economic and environmental health depends on:

1. Promoting efficient development and land use which stimulate economic growth while protecting the environment and public health.
2. Protecting resources for their economic and environmental benefits.
3. Reducing the potential for long term public cost or risk to Ontario's residents by directing development away from areas where there is a risk to public health or safety or of property damage.

III. Policies

3. Public Health and Safety

- 3.1 Development will generally be directed to areas outside of:
 - hazardous lands adjacent to the shorelines of the Great Lakes - St. Lawrence River System which are impacted by flooding, erosion, and/or dynamic beach hazards.
- 3.2 Development and site alteration will not be permitted within:
 - defined portions of the dynamic beach.
- 3.3 Except for those areas identified in 3.2, development and site alteration may be permitted in hazardous areas, provided that all of the following can be achieved:
 - the hazards can be safely addressed;
 - new hazards are not created and existing hazards are not aggravated;
 - no adverse environmental impacts will result;
 - vehicles and people have a way of safely entering and exiting the area during times of flooding, erosion and other emergencies;
 - the development is carried out in accordance with established standards and procedures; and,
 - the development does not involve institutional uses or essential emergency services or the disposal, manufacture, treatment or storage of hazardous substances.

IV. Implementation/Interpretation

This provincial policy statement is issued under Section 3 of the Planning Act by the Ministry of Municipal Affairs and Housing, in conjunction with other ministries. Section 3 of the Planning Act requires that, in exercising any authority that affects planning matters, planning authorities "shall have regard to" policies adopted under the Act.

These policies should be read in their entirety, and all applicable policies applied to each situation. Nothing in these policies is intended to prevent planning authorities from going beyond the minimum standards established in any of these policies, unless doing so would conflict with any other policy.

1. Once the policy statement comes into effect, planning authorities "shall have regard to" the policies in making decisions on all applications which were commenced on or after March 28, 1995 and in respect of which no decision has been made.
2. Implementation guidelines are advisory and will provide information on the meaning of the policies.
3. Ministries will provide available information to planning jurisdictions on matters of provincial significance outlined in policy statements, and may assist planning jurisdictions in mapping these matters and developing their policies.
4. These policies are to be applied in dealing with planning matters. Official plans will integrate all applicable provincial policies and apply appropriate land use designations and policies. Where applications are submitted under the Planning Act and any other act, all applicable policies and provisions should apply where reasonable.
6. The Province will identify performance indicators for measuring the effectiveness of some or all of the policies, and monitor their implementation. Municipalities are encouraged to establish performance standards to monitor the implementation of the policies in their official plans.

DEFINITIONS

The Provincial Policy Statement includes definitions which provide further description of the hazardous lands and direction on delineation of the flooding, erosion and dynamic beach hazard limits.

Hazardous Lands:

means property or lands that could be unsafe for development due to naturally occurring processes. Along the shorelines of the Great Lakes - St. Lawrence River System, this means the land, including that covered by water, between the international boundary, where applicable, and the furthest landward limit of the flooding, erosion or dynamic beach hazard limits.

Development:

means the subdivision of land, a change in land use, or construction of buildings and structures, requiring approval under the Planning Act; but does not include activities that create or maintain infrastructure authorized under an environmental assessment process; or works subject to the Drainage Act.

Flooding hazards:

means the inundation of areas adjacent to a shoreline and not ordinarily covered by water. Along the Great Lakes - St. Lawrence River System, the flooding hazard limit is based on the 100 year flood level plus an allowance for wave uprush and other water related hazards.

One Hundred year flood level:

for the shorelines of the Great Lakes, means the peak stillwater level, resulting from combinations of mean monthly lake levels and wind setups, which is equalled or exceeded in 1% of all years.

Wave uprush:

means the rush of water up onto a shoreline or structure following the breaking of a wave; the limit of wave uprush is the point of furthest landward rush of water onto the shoreline.

Erosion hazards:

means the loss of land, due to human or natural processes, that poses a threat to life and property. The erosion hazard limit is determined using the 100 year erosion rate (the average annual recession extended over a hundred year time span), an allowance for slope stability, and/or an erosion allowance (eg. toe and erosion protection).

Established standards and procedures:

means the following:

Floodproofing standard, which means the combination of measures incorporated into the basic design and/or construction of buildings, structures, or properties to reduce or eliminate flooding hazards associated with wave uprush and other water related hazards along the shorelines of the Great Lakes - St. Lawrence River System.

Protection works standard, which means the combination of non-structural or structural works and allowances for slope stability and flooding/erosion to reduce the damages caused by flooding, erosion, and other water related hazards, and to allow access for their maintenance and repair.

Access standard, which means a method or procedure to ensure safe vehicular and pedestrian movement, and access for the maintenance and repair of protection works, during times of flooding, erosion and/or other water related hazards.

Dynamic Beach Hazards:

means areas of inherently unstable accumulations of shoreline sediments along the Great Lakes - St. Lawrence River System. The dynamic beach hazard limit includes the flooding hazard limit plus a dynamic beach allowance.

Defined portions of a dynamic beach:

means those portions of the dynamic beach which are highly unstable and/or critical to the natural protection and maintenance of the first main dune feature and/or beach profile, where any development or site alteration would create or aggravate flooding or erosion hazards, cause updrift and/or downdrift impacts and/or cause environmental impacts.

3.3 Local Conditions

The principles of Natural Hazards Management outlined under Section 3.0 recognize that local conditions and degree of development risk vary from shoreline to shoreline. The local conditions of the study area shoreline which need to be considered fall into three categories as they relate to development, natural processes and shoreline recession and erosion.

DEVELOPMENT AND TRENDS

There are approximately 1000 individual properties fronting on the shoreline within the study area. The majority of these properties are developed with single family residential dwellings. Several cottage communities are located at the northeast section of the study area. Municipal and conservation authority operated parks form the majority of public open space along the shoreline. Municipal road allowances running parallel or perpendicular to the shoreline provide significant additional public access. In general, the shoreline is fully developed with few areas available for subdivision development or multi-lot severances.

The development trend in the cottage communities has been to convert from seasonal use to permanent year round residential use. These conversions have often been accompanied by increases in living space through the construction of additions. Within permanent residential development areas, extensive redevelopment of properties has taken place. This redevelopment has consisted mainly of replacement of older dwellings with new homes. In the City of Sarnia, the severance and development of larger lakefront properties has been experienced. In Plympton Township, many vacant lots of record within historic registered plans, have recently been developed.

In 1992, properties within the County of Lambton were reassessed based on market values from 1988. The reassessment resulted in substantial increases in assessed values for properties fronting on Lake Huron. In many areas, the assessed value of properties substantially exceeded the value of dwellings on the lots. It is expected that future purchasers of these properties would be encouraged to redevelop in order to construct dwellings that match the value of the properties.

The recent provision of municipal services including water and sanitary sewers in Plympton Township can be expected to encourage the development trends outlined above. These services have been partially funded by the Province of Ontario as a means to address existing water quality problems related to drinking water and beach closures along Lake Huron. The high cost of these services in Plympton Township can be expected to encourage redevelopment and conversion trends. It will be important to ensure that redevelopment is directed to the least hazardous portions of these shoreline properties.

NATURAL SHORELINE PROCESSES

The predominant form of protection works along the study area shoreline are steel sheet pile groynes. These structures interrupt the natural movement of littoral materials (the sediments along the shoreline) to create wider, more stable beaches adjacent the bluffs. The supply of beach material (sand and gravel) is principally provided by the erosion of the bluffs, although smaller quantities are also supplied by erosion of the nearshore lake bottom, erosion of gullies, and discharge from rivers and creeks. As material is deposited in the nearshore area, it is transported along the shoreline by waves and wave-induced currents, in a general direction from northeast to southwest (Kettle Point to Sarnia).

Erosion of the bluffs to the northeast of Brights Grove provides a significant quantity of sediment to "feed" the beaches to the southwest. Clearly, if all the eroding bluffs to the northeast of Brights Grove were fully protected, this would have a significant impact on the groyne fields and beaches to the southwest. The existing protection, however, does not fully protect the bluffs from erosion, particularly during severe storms at high lake levels.

Groynes selectively trap the coarser sand and gravel materials and allow the finer silt and clay sediments to move on. The stability of the beaches is dependent on a continuous supply of sand from the "updrift" shoreline (i.e. the shoreline to the northeast). Where the movement of appropriately coarse littoral material is interrupted with greater frequency, existing groyne cells may fail to remain full in the future resulting in erosion of protective beaches.

SHORELINE RECESSION AND EROSION

Much of the study area shoreline is generally stable with low long term recession rates. The stability of these areas is typically confirmed by well vegetated bluffs with mature trees and the presence of wide beaches. Within the study area there are some high risk shoreline areas with erosion rates greater than 0.3 metres per year. In these areas the bluffs are steep and eroding, and beaches are narrow or non-existent.

Virtually the entire shoreline is susceptible to recurring damages to protection works and property resulting from wave impact during high magnitude storm events. Serious loss of property has resulted through the erosion of beach and bluff materials. Severe storms in March 1973, November 1983 and November 1986 caused widespread damages. The costs to private landowners and municipalities to restore property and protection works have been significant. Development located in close proximity to the shoreline bluff or protection works continues to be susceptible to erosion damage.

3.4 Shoreline Development Guidelines

Development guidelines for the study area shoreline will address the principles of Natural Hazards Management, have regard to the provincial policies, recognize local conditions and encourage improved development and redevelopment practices.

Further direction and clarification on the provincial policy and hazard lands delineation is provided in the implementation guidelines prepared to support the Provincial Policy Statement.

3.4.1 HAZARDOUS LANDS DELINEATION

Flooding Hazard Limit - The standard used to define the flood hazard limit is the 100 year flood level plus an allowance for wave uprush and other water related hazards. The recommended allowance for wave uprush appropriate for the study area is 15 metres measured horizontally from the 100 year flood line.

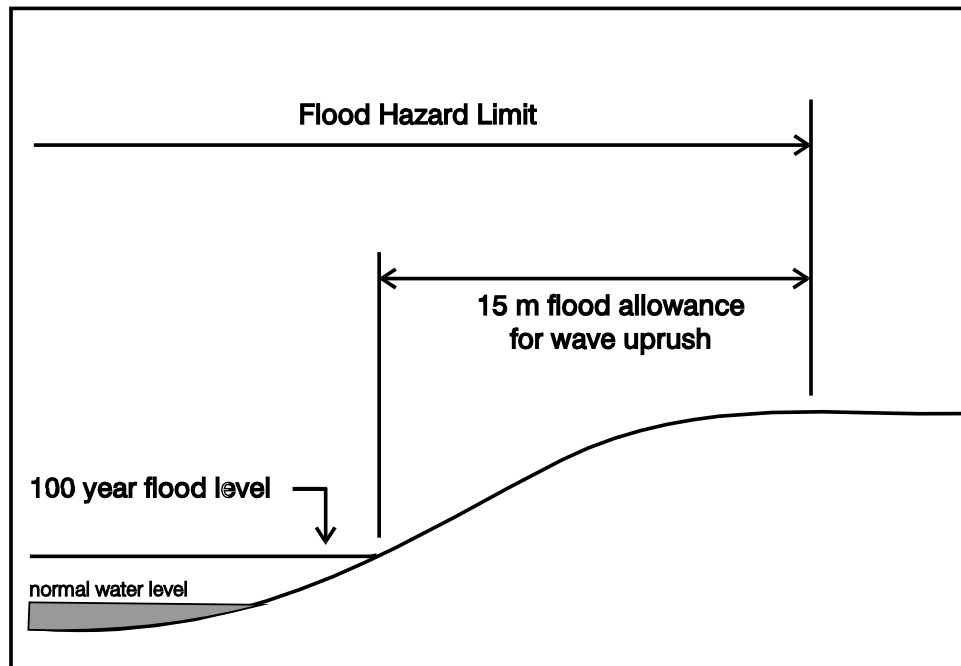


Figure 2

Flood Hazard Limit

The 100 year flood level for the shoreline north of Blue Point in Plympton Township is 177.9 metres G.S.C. (Geodetic Survey of Canada Datum). The 100 year flood level for the shoreline south of Blue Point is 178.0 metres.

Wave uprush is controlled by site specific factors such as nearshore water depths, nearshore slopes and protection works which can vary from property to property. Wave uprush at a specific property can be determined by conducting studies using accepted engineering principles. In recognition of local conditions, the boundary of the flood hazard limit can be relocated to reflect site specific information.

Erosion Hazard Limit - The standard used to define the erosion hazard limit is the sum of the slope stability allowance plus 100 times the average annual recession rate measured landward from the toe of the bluff or a 30 metre erosion allowance measured landward from the top of the bluff (WHICHEVER IS GREATER).

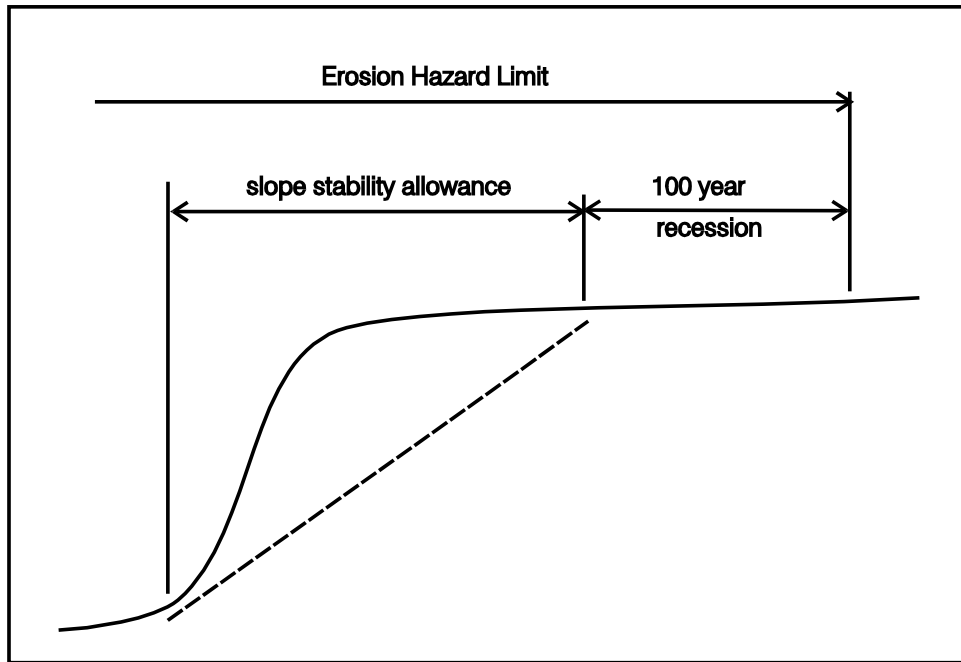


Figure 3

Erosion Hazard Limit

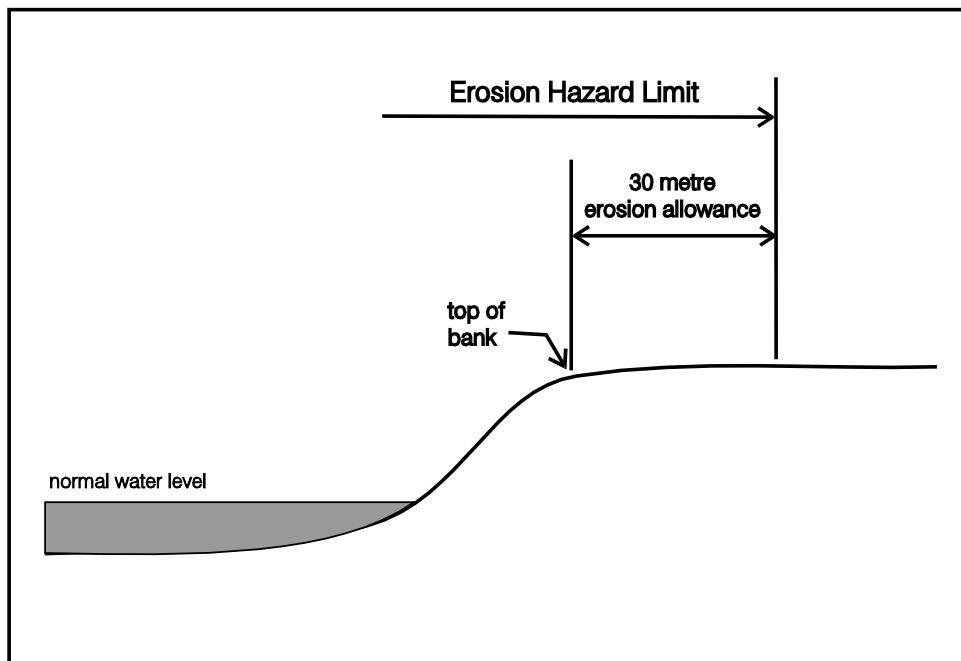


Figure 4

Erosion Hazard Limit

Slope Stability Allowance - The stable slope allowance appropriate for the study area is a horizontal setback measured landward from the toe of the bluff equivalent to 3.0 times the difference in elevation between the first lakeward break in slope and the toe of the bluff.

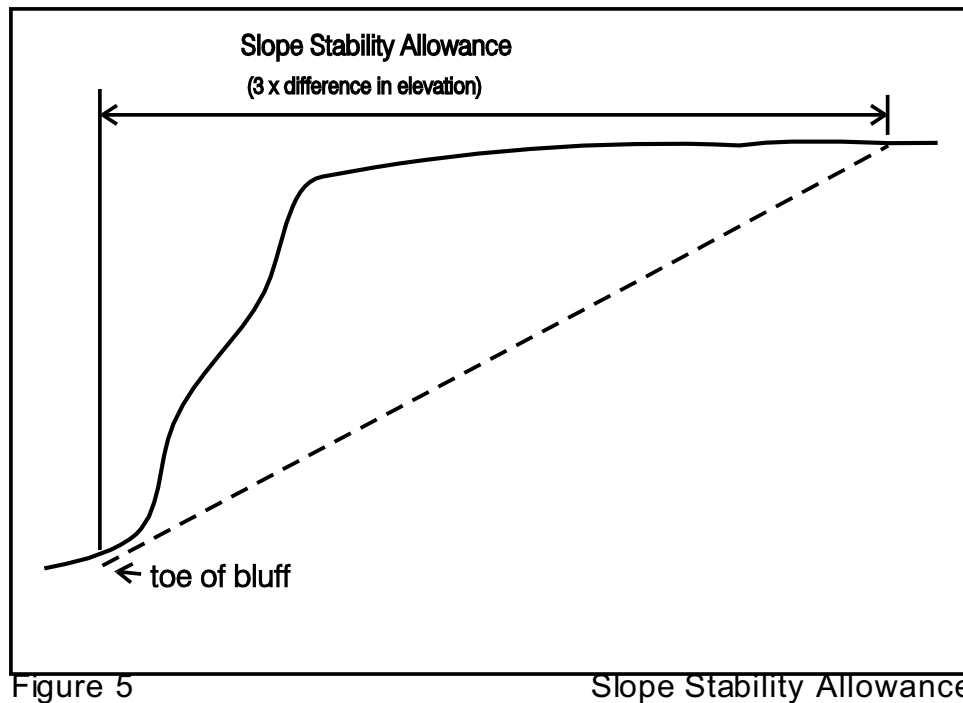


Figure 5

Slope Stability Allowance

Slope stability is controlled by site specific factors such as soil type and groundwater levels which can vary from property to property. The stable slope allowance can be determined for a specific property by conducting studies using accepted geotechnical engineering principles. In recognition of local conditions, the stable slope allowance will be modified to reflect site specific information.

Average annual recession rates were determined by comparing bluff features shown on a historical shoreline survey from 1934 with features shown on topographic mapping completed in 1989. Where recession rates are determined using information of similar accuracy and duration such as registered plans and property surveys, the average annual recession rate will be modified to reflect the site specific information.

The 30 metre erosion allowance recognizes several factors including but not limited to the following:

- uncertainties in recession rate data, nearshore downcutting processes, wave data, shoreline processes;
- limited design life of protection works;
- inability to enforce long-term maintenance requirements;
- some uncertainty with respect to structure performance (armourstone stability, wave overtopping, toe scour);
- condition and effectiveness of any adjoining protection works;
- provision of an environmental buffer strip along the shoreline; and,
- allows for access during emergencies

3.4.2 MANAGEMENT AREA DELINEATION

Prohibiting or restricting development within the Hazardous Lands will protect new development from the shoreline hazards. Implementation of the provincial policy is straightforward when dealing with new development related to subdivision development and multi-lot severances. However, applying shoreline guidelines to existing developments or existing undeveloped lots becomes more complex. For this reason, the standards used to define the Hazard Land Limits, are further classified into Management Areas, in order to address local conditions within the context of Natural Hazards Management principles and provincial policies.

Management areas will be based on the characteristics of the shoreline related to bluff height and beach development. Within high bluff areas (bluff height greater than 5 metres) management areas utilize criteria outlined under the erosion hazard limit. In low bluff and beach areas (bluff height less than 5 metres) management areas utilize a combination of criteria outlined under both the erosion hazard limit and the flooding hazard limit.

Community Prescription maps located in Section 4 of the SMP show the delineation of both Shoreline Area 1 and Shoreline Area 2 on each shoreline property as described below.

HIGH BLUFF AREAS

Shoreline Area 1 - That area of the shoreline between the water's edge and a line defined by the stable slope allowance including the beach, the face of the bluff and the table land extending from the top of the bluff to the limit of the slope stability allowance.

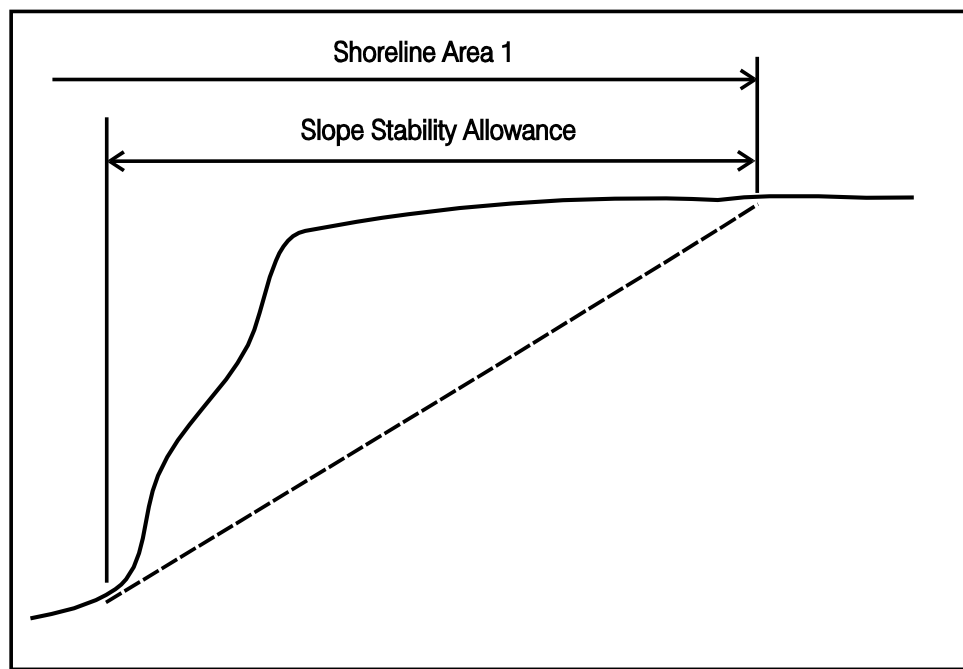


Figure 6

High Bluff Areas
Shoreline Area 1

Shoreline Area 1, delineated by the slope stability allowance, identifies the area of greatest erosion concern where the bluff may be susceptible to massive failure in the form of slumping and sliding. Bluff movement or instability can occur in many ways but is generally the result of:

- changes in slope configuration (steepness or inclination)
- increases in loading on a slope (structures or filling near the crest)

- changes in drainage of the soil which create higher water levels or water pressures (heavy rainfall, blocked drainage, broken service connections)
- loss of vegetation

Bluff movement can occur over a relatively short period of time and often with little warning. Where existing dwellings become at risk or are damaged by bluff instability, movement of these structures becomes an emergency operation. Access to properties with buildings damaged by bluff movement can be restricted due to additional equipment loading and proximity to top of bluff. These factors increase the emergency cost of moving the structure.

Shoreline Area 2 - That area of the shoreline between Shoreline Area 1 and a line defined by the slope stability allowance plus the distance that the shoreline is estimated to recede over a 100 year period or, a 30 metre erosion allowance measured landward from the top of the bluff (erosion hazard limit).

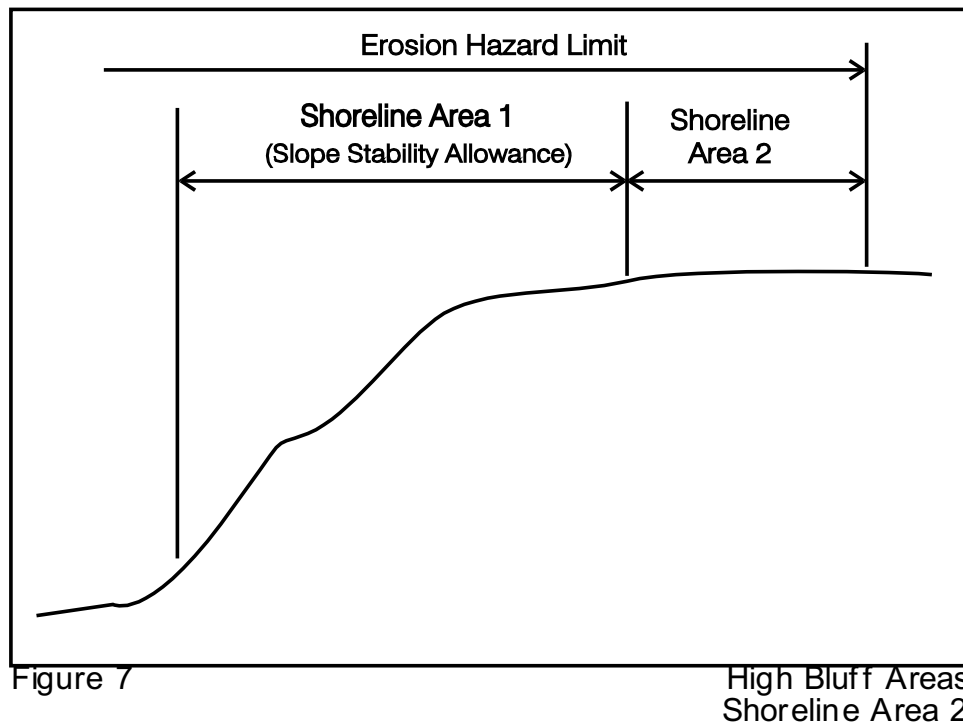


Figure 7

High Bluff Areas
Shoreline Area 2

Shoreline Area 2, delineated by 100 years of erosion, addresses the long term recession of the bluff. The 30 metre erosion allowance addresses uncertainties associated with natural shoreline processes and the performance of protection works.

LOW BLUFF AND BEACH AREAS

Shoreline Area 1 - That area of the shoreline between the water's edge and a line defined by the 100 year flood level plus an allowance for wave uprush and other water related hazards (flooding hazard limit).

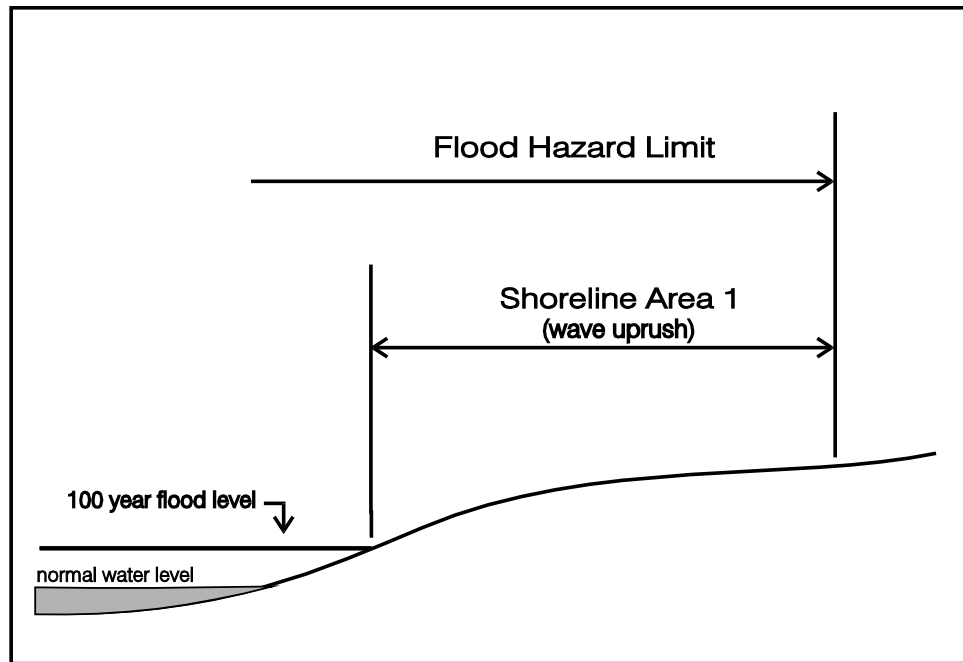
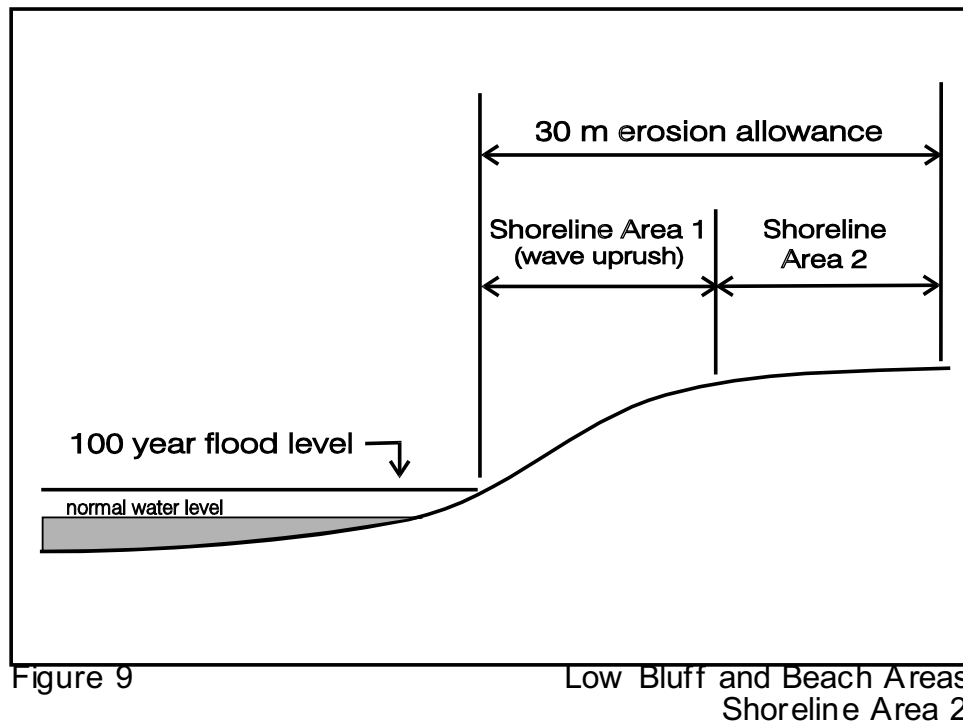


Figure 8

Low Bluff and Beach Areas
Shoreline Area 1

The lands adjacent the shoreline susceptible to wave uprush have historically experienced erosion with damages to protection works and resultant property losses. During high lake level periods, beaches become submerged. During storm events, lake levels increase further due to wind setup allowing larger and more powerful waves to reach the bluffs and protection works. Where buildings and structures are located within the wave uprush area, protection works and the existence of beach materials become vital. Where protection works are damaged or fail entirely during high magnitude storm events, significant erosion damages to property and buildings can take place.

Shoreline Area 2 - That area of the shoreline between Shoreline Area 1 and a line defined by the 100 year flood level plus a 30 metre erosion allowance.



Shoreline Area 2 addresses long term recession resulting from beach and bluff erosion. The 30 metre erosion allowance recognizes uncertainties associated with natural shoreline processes and the performance of protection works. Concerns regarding protection works relate to design life, maintenance, and condition of adjacent structures. Dwellings constructed landward of Shoreline Area 2 will not rely on protection works to prevent erosion and damage to the building.

A summary of development guidelines applicable to shoreline properties can be found in Table 1. This table was derived from discussions of the SCRCA Shoreline Management Advisory Committee. The table introduces the various development activities which are commonly undertaken on shoreline properties within the study area and provides direction on the appropriateness of these activities within each of the delineated management areas. These guidelines can be compared against the existing municipal planning policies implemented through the Official Plans and Comprehensive Zoning By-laws for the City of Sarnia and the Township of Plympton. Excerpts from these policies are reproduced in Appendix A.

It is important to note that any activities on shoreline properties must adhere to other municipal planning policies (i.e. zoning by-law setbacks) in effect.

Table 1

SHORELINE DEVELOPMENT GUIDELINES

<u>Development Type</u>	<u>Shoreline Area 1</u>	<u>Shoreline Area 2</u>
repairs/maintenance	- permitted	- permitted
interior alterations	- permitted	- permitted
additions ¹	- could be permitted provided no further encroachment lakeward and <i>flooding and/or erosion hazards are appropriately addressed</i> ²	- could be permitted provided no encroachment into Area 1
unattached garages	- should not be permitted	- could be permitted provided that <i>flooding and/or erosion hazards are appropriately addressed</i> ²
septic systems	- should not be permitted	- could be permitted provided that <i>flooding and/or erosion hazards are appropriately addressed</i> ²
new dwellings	- should not be permitted	- could be permitted provided that <i>flooding and/or erosion hazards are appropriately addressed</i> ²
rebuilding of dwelling	- could be permitted provided that <i>flooding and/or erosion hazards are appropriately addressed</i> ²	- could be permitted provided that <i>flooding and/or erosion hazards are appropriately addressed</i> ²
destroyed by forces other than flooding and/or erosion	- should not be permitted	- should not be permitted
severances and subdivisions	- should not be permitted	- could be permitted provided that <i>flooding and/or erosion hazards are appropriately addressed</i> ²
infilling severances		

¹ It will be necessary for the municipalities to further define the concept of additions when incorporating shoreline policies into their planning documents. The size, location and hazards associated with existing development within the study area can vary considerably. In order to reduce the potential damage costs, limits should be imposed on the size of additions permitted in each of the management areas. Permissible addition sizes could be based on a maximum percentage increase in the size of the existing dwelling or a maximum area (square footage) increase in the size of the existing dwelling.

² Addressing the flooding and/or erosion hazards in conjunction with the development or redevelopment of a shoreline property can take the form of structural or non-structural measures, or a combination of these measures meant to reduce potential damages. These measures may include (but are not limited to) moveable dwelling designs, dwelling relocation, bluff stabilization measures, protection works, drainage, and beach nourishment. Where protection works are proposed as a means to address the hazards, these works should meet established standards and procedures. The various hazards to be addressed in each of the management areas are described in detail under Section 3.4.2.

WOODROWE AVENUE - ANDOVER LANE

(Lots 68 to 65, Front Concession)
City of Sarnia

Map Sheets #7 and #8 (Measurement Numbers 032-049)

Shoreline Characteristics

- beach - sand beach typically \pm 15 metres wide at normal summer water levels, becoming narrower during periods of high lake levels
- bluff - low bluff; natural bluff composed of sand materials which are part of a massive natural sand deposit which formed a recurved spit from the St. Clair River to approximately Telfer Sideroad
- development - permanent residential development located at and along the top of bluff
- protection works - steel sheet-pile groynes; some groynes supplemented with vertical sheet-pile seawalls

Erosion Issues

- long term top of bank recession rate is generally $<$ 0.3 metres/year
- beach erosion and wave uprush damage
- historical damages to protection works and property during high magnitude storm events
- turbulence created by wave reflection off vertical seawalls and groynes may contribute to removal of beach materials
- during storm events, wave action can temporarily overrun the beach and directly attack the shoreline bluff and protection works

Objective of Protection Works

- limit storm wave uprush and damage
- provide recreational beach

Recommendations

- maintain existing groynes
- during periods of high lake levels, "nourish" existing groyne cells with suitable beach sand (clean sand and gravel, $D_{50} > 0.3\text{mm}$)
- damaged seawalls should be replaced with sloping rubblemound revetments
- where additional protection from wave uprush is necessary, recommended approach is rubblemound revetment
- for more detailed information and guidance, refer to the supporting document entitled Design Considerations for Shore Protection Structures (Baird, 1992), and MNR(1986) and USACOE (1977, 1981)

Management Area Delineation

- Shoreline Area 1 - between the water's edge and a line defined by the 100 year flood line plus a 15 metre wave uprush allowance (Flood Hazard Limit)
- Shoreline Area 2 - between Shoreline Area 1 and a line defined by the 100 year flood line plus a 30 metre erosion allowance.

Woodrowe Ave-Andover Ln

Legend

- Shoreline Area 1
- Shoreline Area 2

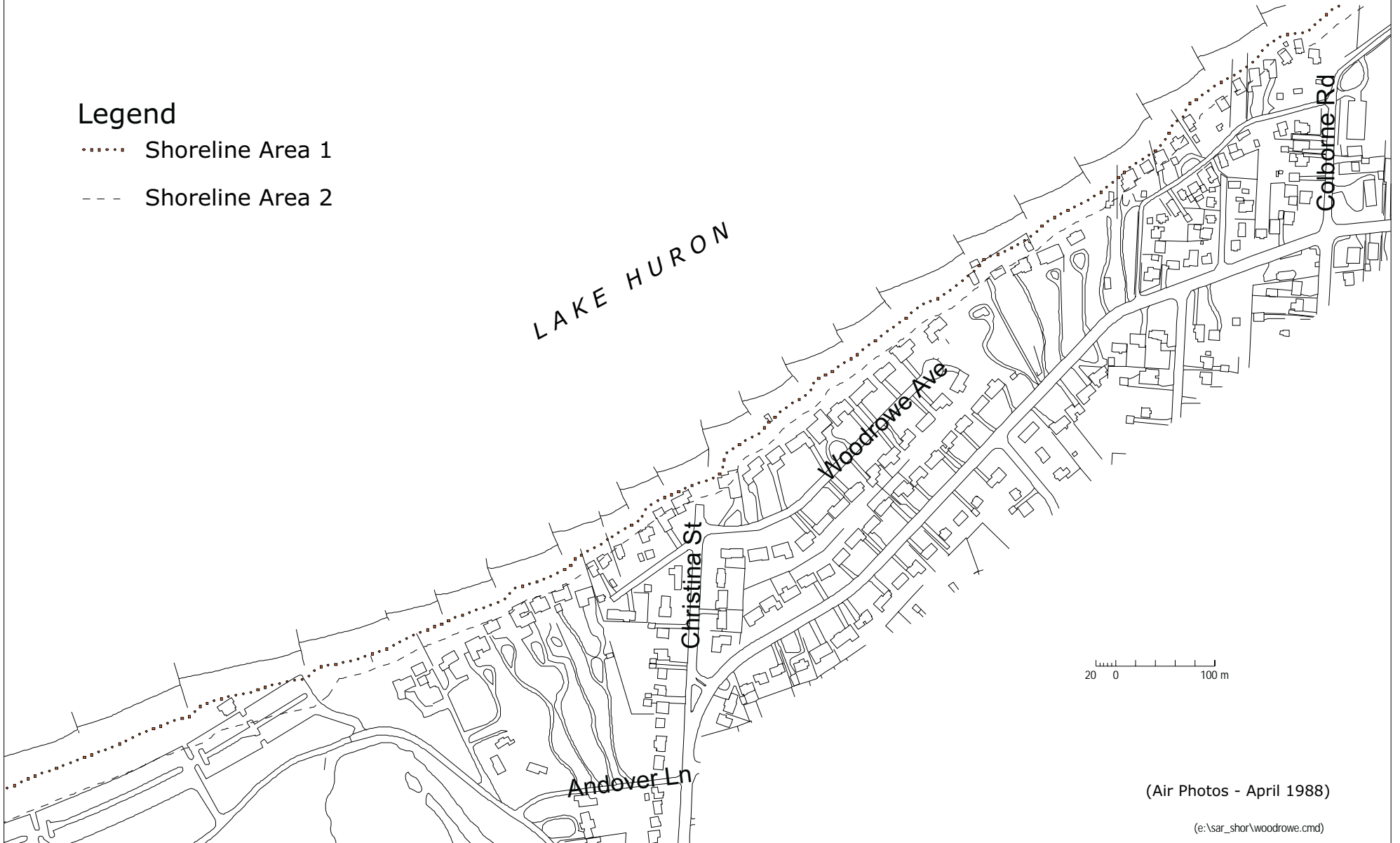


Figure 10

(Air Photos - April 1988)

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BEACH LANE - GRANT STREET - TUDOR CLOSE - EDGEWATER CRESCENT

(Lots 64 to 56, Front Concession)

City of Sarnia

Map Sheets #7 and #8 (Measurement Numbers 050-088)

Shoreline Characteristics

- beach - sand beach typically \pm 10 metres wide at normal summer water levels, becoming narrower during periods of high lake levels
- bluff - low bluff; natural bluff composed of sand materials which are part of a massive natural sand deposit which formed a recurved spit from the St. Clair River to approximately Telfer Sideroad
- development - permanent residential development located at and along the top of bluff
- protection works - steel sheet-pile groynes; many groynes supplemented with vertical sheet-pile seawalls and sheet-pile and concrete retaining walls
 - broken concrete and other construction materials used in sloping rubblemound revetment at some locations

Erosion Issues

- long term top of bank recession rate is generally < 0.3 metres/year
- beach erosion and wave uprush damage
- historical damages to protection works and property during high magnitude storm events
- turbulence created by wave reflection off vertical seawalls and groynes may contribute to removal of beach materials
- during storm events, wave action can temporarily overrun the beach and directly attack the shoreline bluff and protection works

Objective of Protection Works

- limit storm wave uprush and damage
- provide recreational beach

Recommendations

- vertical seawalls and retaining walls are not recommended
- maintain existing groynes
- during periods of high lake levels, "nourish" existing groyne cells with suitable beach sand (clean sand and gravel, $D_{50} > 0.3\text{mm}$)
- damaged seawalls should be replaced with sloping rubblemound revetments
- where additional protection from wave uprush is necessary, recommended approach is rubblemound revetment
- for more detailed information and guidance, refer to the supporting document entitled Design Considerations for Shore Protection Structures (Baird, 1992), and MNR(1986) and USA COE (1977, 1981)

Management Area Delineation

- Shoreline Area 1 - between the water's edge and a line defined by the 100 year flood line plus a 15 metre wave uprush allowance (Flood Hazard Limit)
- Shoreline Area 2 - between Shoreline Area 1 and a line defined by the 100 year flood line plus a 30 metre erosion allowance.

Beach Ln-Tudor Cl-Winton Rd-Edgewater Cr

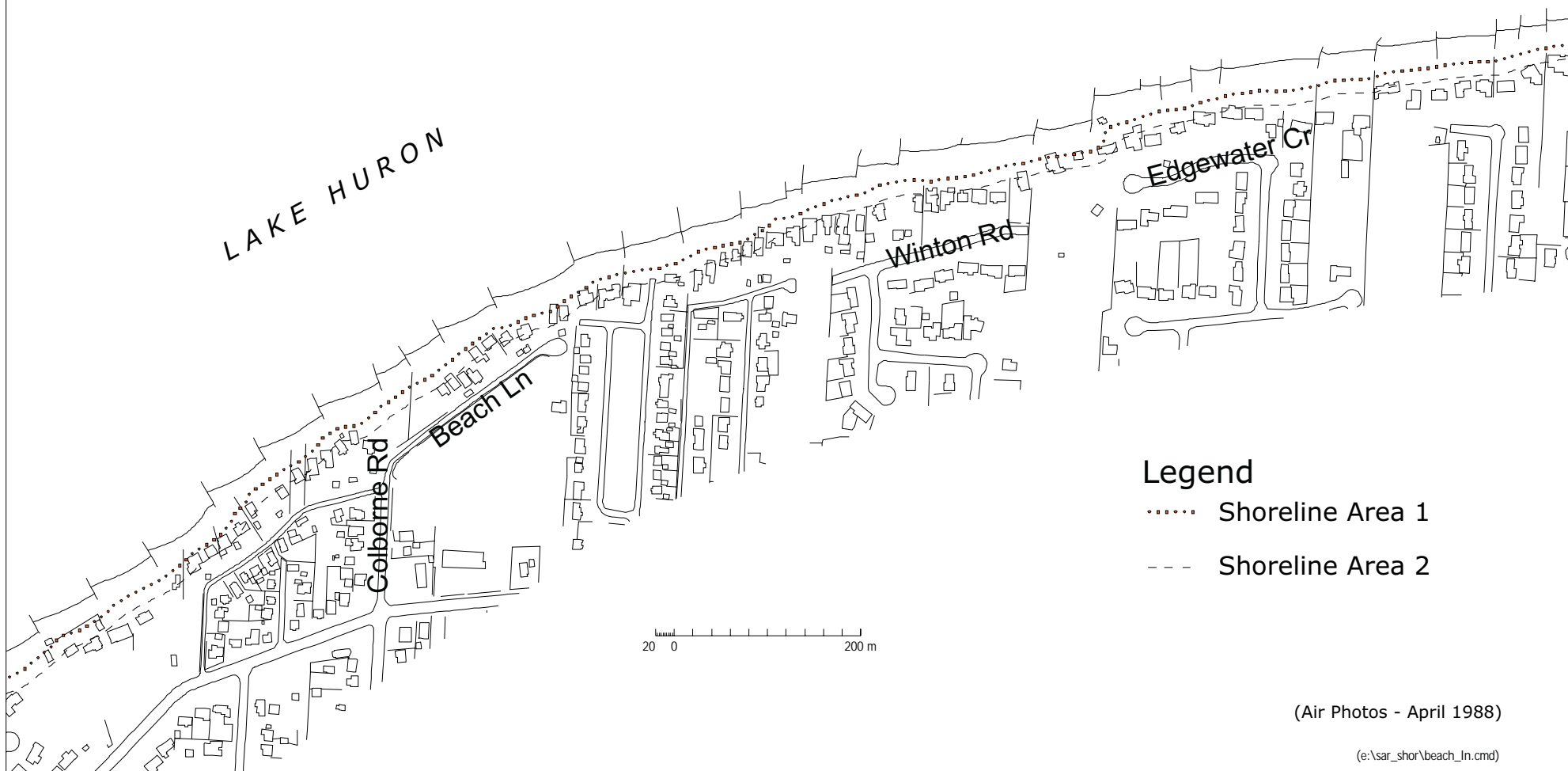


Figure 11

BRAEMAR LANE - HAIGHT LANE - LAKE HURON PARKWAY

(Lots 55 to 53, Front Concession)

City of Sarnia

Map Sheet #8 (Measurement Numbers 089-102)

Shoreline Characteristics

- beach - sand beach typically \pm 10 metres wide at normal summer water levels, becoming narrower during periods of high lake levels
- bluff - low bluff; natural bluff composed of sand materials which are part of a massive natural sand deposit which formed a recurved spit from the St. Clair River to approximately Telfer Sideroad
 - in many areas the natural slope has been replaced with bluff stabilization measures (grading, filling, etc.) due to past erosion events
- development - permanent residential development located at the top of bluff and on the bluff face
- protection works - steel sheet-pile groynes supplemented with vertical sheet-pile seawalls

Erosion Issues

- long term top of bank recession rate is generally < 0.3 metres/year
- beach erosion and wave uprush damage
- historical damages to protection works and property during high magnitude storm events
- turbulence created by wave reflection off vertical seawalls and groynes may contribute to removal of beach materials
- during storm events, wave action can temporarily overrun the beach and directly attack the shoreline bluff and protection works

Objective of Protection Works

- limit storm wave uprush and damage
- provide recreational beach

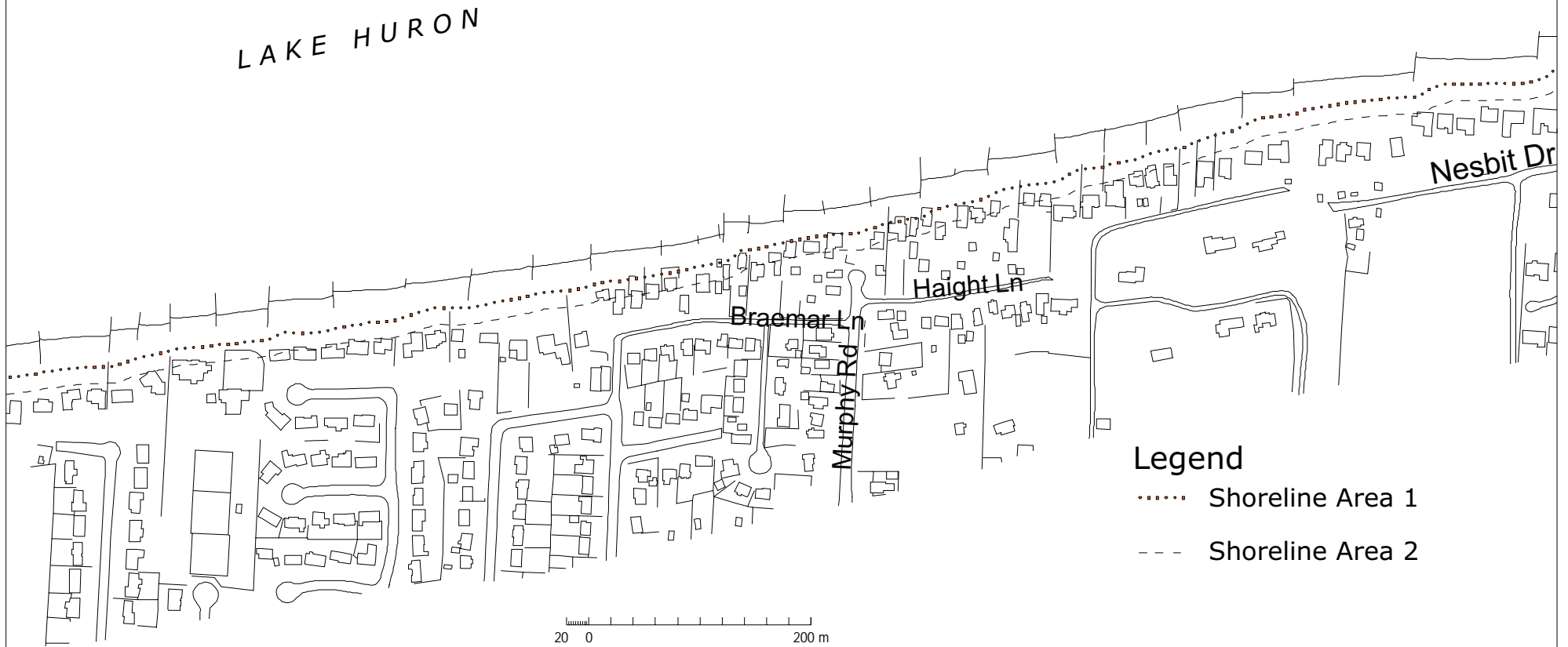
Recommendations

- vertical seawalls and retaining walls are not recommended
- maintain existing groynes
- during periods of high lake levels, "nourish" existing groyne cells with suitable beach sand (clean sand and gravel, $D_{50} > 0.3\text{mm}$)
- supplement or replace existing seawalls with sloping rubblemount revetments
- as part of overall shoreline protection scheme, property owners should consider relocation of existing dwellings currently located on the bluff face
- for more detailed information and guidance, refer to the supporting document entitled Design Considerations for Shore Protection Structures (Baird, 1992), and MNR(1986) and USACOE (1977, 1981)

Management Area Delineation

- Shoreline Area 1 - between the water's edge and a line defined by the 100 year flood line plus a 15 metre wave uprush allowance (Flood Hazard Limit)
- Shoreline Area 2 - between Shoreline Area 1 and a line defined by the 100 year flood line plus a 30 metre erosion allowance.

Braemar Ln-Haight Ln-Lake Huron Pkwy



Legend

- Shoreline Area 1
- Shoreline Area 2

(Air Photos - April 1988)

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Figure 12

HILLCREST DRIVE - NESBIT DRIVE - LAKESHORE ROAD - CORONATION LANE

(Lots 52 to 46, Front Concession)

City of Sarnia (formerly Town of Clearwater)

Map Sheets #8 and #9 (Measurement Numbers 103-131)

Shoreline Characteristics

- beach - sand beach typically \pm 10 metres wide at normal summer water levels, becoming narrower during periods of high lake levels
- bluff - low bluff; natural bluff composed of sand materials which are part of a massive natural sand deposit which formed a recurved spit from the St. Clair River to approximately Telfer Sideroad
- development - permanent residential development located at and along the top of bluff
- protection works - steel sheet-pile groynes; many groynes supplemented with vertical sheet-pile seawalls and sheet-pile and concrete retaining walls
 - broken concrete and other construction materials used in sloping rubblemound revetment at some locations

Erosion Issues

- long term top of bank recession rate is generally $<$ 0.3 metres/year
- beach erosion and wave uprush damage
- historical damages to protection works and property during high magnitude storm events
- turbulence created by wave reflection off vertical seawalls and groynes may contribute to removal of beach materials
- during storm events, wave action can temporarily overrun the beach and directly attack the shoreline bluff and protection works

Objective of Protection Works

- limit storm wave uprush and damage
- provide recreational beach

Recommendations

- vertical seawalls and retaining walls are not recommended
- maintain existing groynes
- during periods of high lake levels, "nourish" existing groyne cells with suitable beach sand (clean sand and gravel, $D_{50} > 0.3\text{mm}$)
- damaged seawalls should be replaced with sloping rubblemound revetments
- where additional protection from wave uprush is necessary, recommended approach is rubblemound revetment
- for more detailed information and guidance, refer to the supporting document entitled Design Considerations for Shore Protection Structures (Baird, 1992), and MNR(1986) and USA COE (1977, 1981)

Management Area Delineation

- Shoreline Area 1 - between the water's edge and a line defined by the 100 year flood line plus a 15 metre wave uprush allowance (Flood Hazard Limit)
- Shoreline Area 2 - between Shoreline Area 1 and a line defined by the 100 year flood line plus a 30 metre erosion allowance.

Nesbit Dr-Lakeshore Rd-Coronation Ln

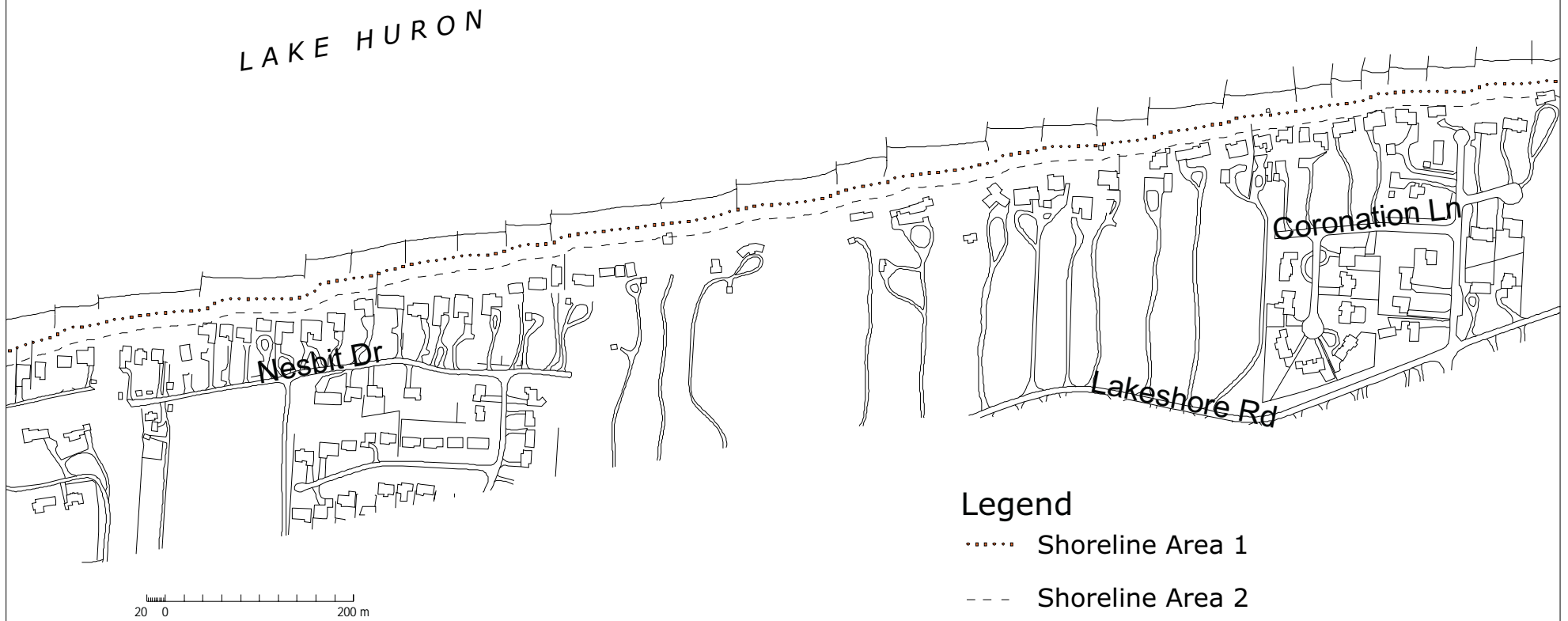


Figure 13

LAKESHORE ROAD

(Modeland Road to Blackwell Sideroad - Lots 45 to 37, Front Concession)
City of Sarnia (formerly Town of Clearwater)

Map Sheets #9 and #10 (Measurement Numbers 132-169)

Shoreline Characteristics

- beach - sand and gravel beach typically \pm 10 metres wide at normal summer water levels, becoming narrower during periods of high lake levels
- bluff - low bluff; natural bluff composed of sand materials which are part of a massive natural sand deposit which formed a recurved spit from the St. Clair River to approximately Telfer Sideroad
 - in many areas the natural slope has been replaced with bluff stabilization measures (grading, filling, etc.) due to past erosion events
- development - permanent residential development located at and along the top of bluff
- protection works - steel sheet-pile groynes supplemented with vertical sheet-pile seawalls and sheet-pile and concrete retaining walls
 - broken concrete and other construction materials used in sloping rubblemound revetments at some locations

Erosion Issues

- long term top of bank recession rate is generally $<$ 0.3 metres/year
- beach erosion and wave uprush damage
- recurring damages to protection works and property during high magnitude storm events
- turbulence created by wave reflection off vertical seawalls and groynes may contribute to removal of beach materials
- during storm events, wave action can temporarily overrun the beach and directly attack the shoreline bluff and protection works

Objective of Protection Works

- limit storm wave uprush and damage
- provide recreational beach

Recommendations

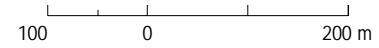
- vertical seawalls and retaining walls are not recommended
- maintain existing groynes; during periods of high lake levels, "nourish" existing groyne cells with suitable beach sand (clean sand and gravel, $D_{50} > 0.3\text{mm}$)
- sloping rubblemound revetment is the recommended approach to protect shoreline from erosion; supplement or replace existing seawalls with sloping rubblemound revetments
- as part of overall shoreline protection scheme, property owners should consider relocation of existing dwellings currently located close to the top of the bluff
- for more detailed information and guidance, refer to the supporting document entitled Design Considerations for Shore Protection Structures (Baird, 1992), and MNR(1986) and USACOE (1977, 1981)

Management Area Delineation

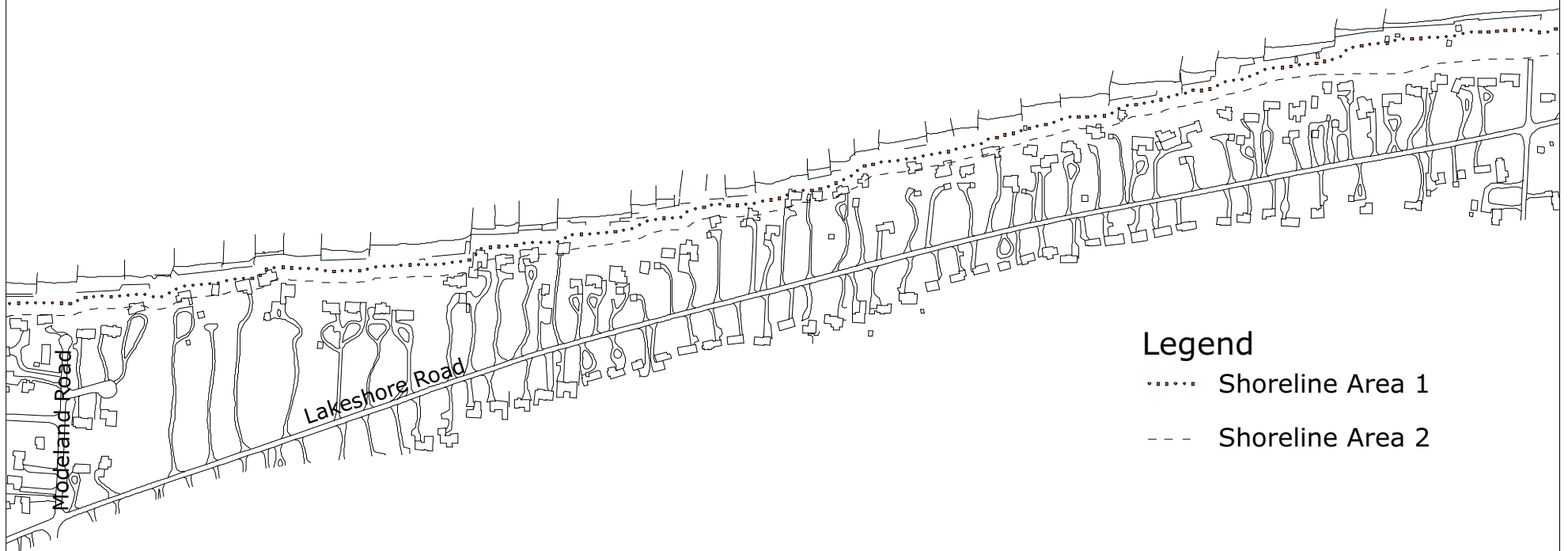
- Shoreline Area 1 - between the water's edge and a line defined by the 100 year flood line plus a 15 metre wave uprush allowance (Flood Hazard Limit)
- Shoreline Area 2 - between Shoreline Area 1 and a line defined by the 100 year flood line plus a 30 metre erosion allowance.

Lakeshore Road

(Modeland Road - Blackwell Sideroad)



LAKE HURON



Legend

- Shoreline Area 1
- Shoreline Area 2

(Air Photos - April 1988)

(e:\sar_shor\lake_rd.cmd)

Figure 14

LAKESHORE ROAD (Blackwell Sideroad to Telfer Sideroad - Lots 36 to 28, Front Concession)
City of Sarnia (formerly Town of Clearwater)

Map Sheets #10 and #11 (Measurement Numbers 170-207)

Shoreline Characteristics

- beach - sand and gravel beach typically \pm 5 metres wide at normal summer water levels, becoming narrower during periods of high lake levels
- virtually no beach sand present in some areas; till material making up the lakebed is regularly exposed at the water's edge
- bluff - natural bluff composed of sand materials which are part of a massive natural sand deposit which formed a recurved spit from the St. Clair River to approximately Telfer Sideroad
- in many areas the natural slope has been replaced with bluff stabilization measures (grading, filling, etc.) due to past erosion events
- development - permanent residential development located at and along the top of bluff
- protection works - steel sheet-pile groynes supplemented with vertical sheet-pile seawalls and sheet-pile and concrete retaining walls

Erosion Issues

- long term top of bank recession rate is generally $<$ 0.3 metres/year
- beach erosion and wave uprush damage
- recurring damages to protection works and property during high magnitude storm events
- turbulence created by wave reflection off vertical seawalls and groynes may contribute to removal of beach materials or prevent deposition of beach materials
- with the absence of beach materials, the nearshore lakebottom is exposed to erosion (downcutting); as the nearshore becomes progressively deeper, the shoreline is exposed to increasingly severe wave attack and potential storm damages

Objective of Protection Works

- stabilize shoreline from future erosion
- limit storm wave uprush and damage
- provide recreational beach

Recommendations

- vertical seawalls and retaining walls are not recommended
- engineered rubblemound revetment is the recommended approach to protect shoreline from erosion; supplement or replace existing seawalls with sloping rubblemound revetments; revetment design must consider beach stability and erosion (downcutting) of the nearshore lakebottom
- maintain existing groynes; during periods of high lake levels, "nourish" existing groyne cells with suitable beach sand (clean sand and gravel, $D_{50} > 0.3\text{mm}$)
- as part of overall shoreline protection scheme, property owners should consider relocation of existing dwellings currently located close to the top of the bluff
- for more detailed information and guidance, refer to the supporting document entitled Design Considerations for Shore Protection Structures (Baird, 1992), and MNR(1986) and USACOE (1977, 1981)

Management Area Delineation

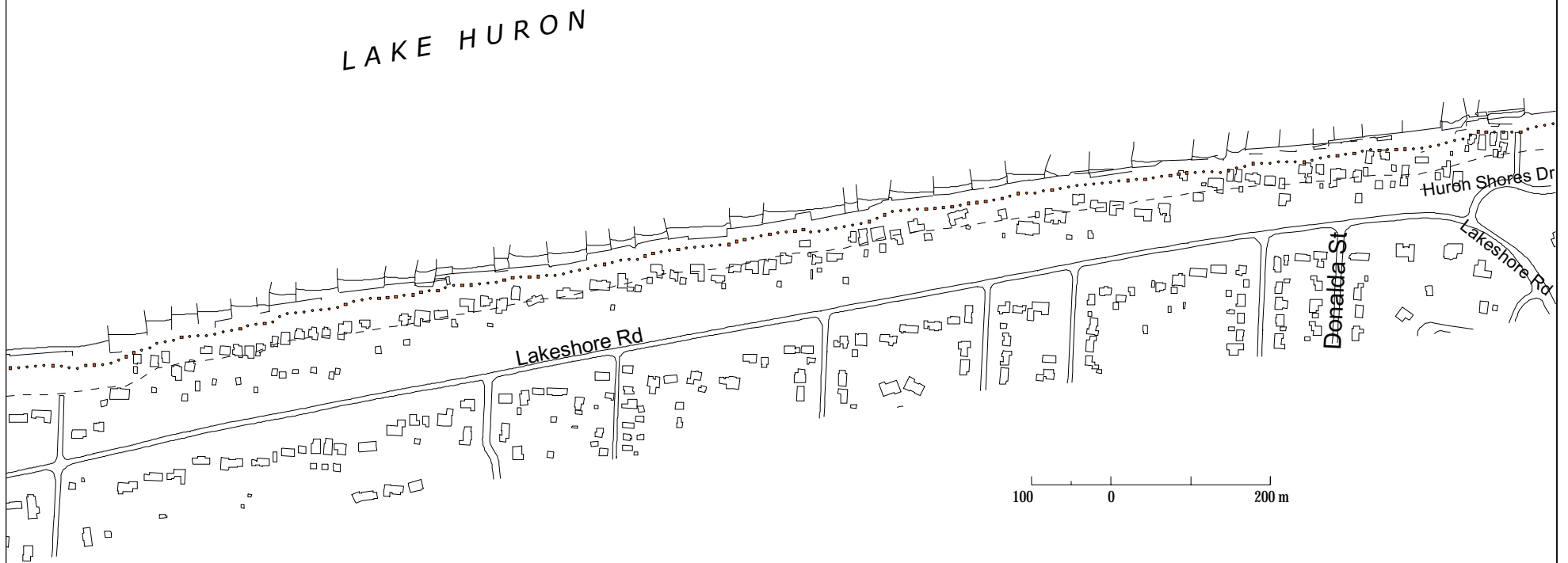
- Shoreline Area 1 - between the water's edge and a line defined by the 100 year flood line plus a 15 metre wave uprush allowance (Flood Hazard Limit)
- Shoreline Area 2 - between Shoreline Area 1 and a line defined by a 30 metre erosion allowance measured from the top of the bluff/bank (Erosion Hazard Limit)

Lakeshore Road

(Blackwell Sideroad - Telfer Sideroad)

Legend

- Shoreline Area 1
- Shoreline Area 2



(Air Photos - April 1988)

(e:\sar_shor\lake_rd2.cmd)

Figure 15

HURON SHORES DRIVE - OLD LAKESHORE ROAD

(Telfer Sideroad to the Cull Drain)

City of Sarnia (formerly Town of Clearwater)

Map Sheet #11 (Measurement Numbers 208-219)

Shoreline Characteristics

- beach - sand and gravel beach typically very narrow at normal summer water levels
 - no beach present during periods of higher lake levels
- bluff - grass covered bank; slope materials made up of poorly draining clay fill; broken concrete and fill dumped over bank to replace eroded slope
- development
 - shoreline bank with paved walkway and paved roadway above are contained within municipal road allowance
 - permanent residential development located south of road allowance on Huron Shores Drive and Old Lakeshore Road
- protection works
 - vertical steel sheet-pile seawall and groynes; approximately 150 metre length of seawall along paved roadway replaced with sloping rubblemound revetment
 - groynes badly damaged by abrasion and ice loading
 - remaining seawall has collapsed in several areas

Erosion Issues

- long term top of bank recession rate is generally < 0.3 metres/year
- beach erosion and wave uprush damage
- historical damages to protection works, municipal infrastructure and property during high magnitude storm events
- with the absence of beach materials, the nearshore lakebottom is exposed to erosion (downcutting); as the nearshore becomes progressively deeper, the shoreline is exposed to increasingly severe wave attack and potential storm damages

Objective of Protection Works

- stabilize shoreline from future erosion
- limit storm wave uprush and damage
- provide recreational beach

Recommendations

- vertical seawalls and retaining walls are not recommended
- engineered rubblemound revetment is the recommended approach to protect shoreline from erosion; supplement or replace existing seawalls with sloping rubblemound revetments
- revetment design must consider beach stability and erosion (downcutting) of the nearshore lakebottom
- for more detailed information and guidance, refer to the supporting document entitled Design Considerations for Shore Protection Structures (Baird, 1992), and MNR(1986) and USA COE (1977, 1981)

Management Area Delineation

- Shoreline Area 1 - between the water's edge and a line defined by the 100 year flood line plus a 15 metre wave uprush allowance (Flood Hazard Limit)
- Shoreline Area 2 - between Shoreline Area 1 and a line defined by a 30 metre erosion allowance measured from the top of the bluff/bank (Erosion Hazard Limit)

Huron Shores Dr-Old Lakeshore Rd

Legend

- Shoreline Area 1
- Shoreline Area 2

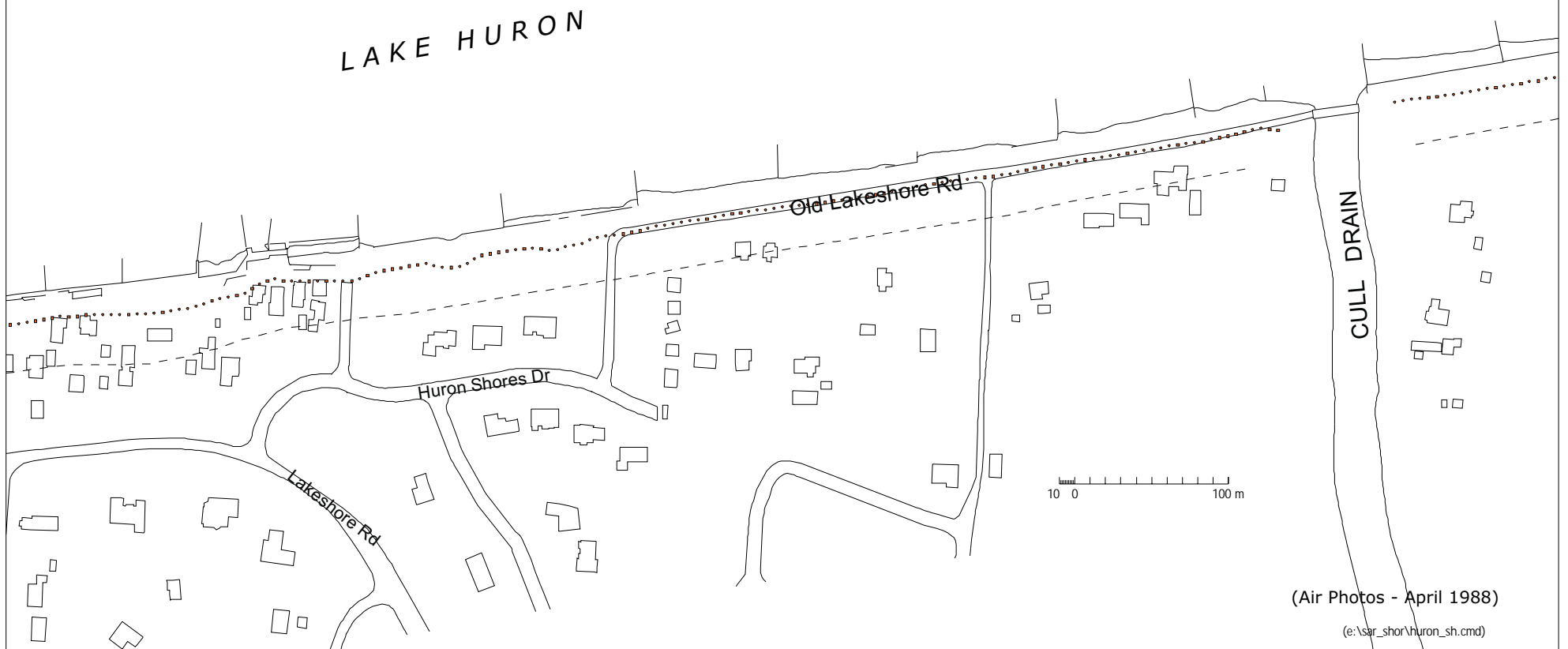


Figure 16

LAMBERT LANE - PASSINGHAM DRIVE

(Cull Drain to Huron View Park)

City of Sarnia (formerly Town of Clearwater)

Map Sheets #11 and #12 (Measurement Numbers 220-295)

Shoreline Characteristics

- beach - sand and gravel beach typically very narrow at normal summer water levels
 - no beach present during periods of higher lake levels
- bluff - grass covered bank; slope materials made up of poorly draining clay fill; broken concrete and fill dumped over bank to replace eroded slope
- development
 - municipal road allowance contains shoreline bank and public trail
 - permanent residential development located south of road allowance
- protection works
 - vertical steel sheet-pile seawall and groynes located within municipal road allowance
 - groynes badly damaged by abrasion and ice loading
 - seawall has collapsed in several areas

Erosion Issues

- long term top of bank recession rate is generally < 0.3 metres/year
- beach erosion and wave uprush damage
- historical damages to protection works, municipal infrastructure and property during high magnitude storm events
- with the absence of beach materials, the nearshore lakebottom is exposed to erosion (downcutting); as the nearshore becomes progressively deeper, the shoreline is exposed to increasingly severe wave attack and potential storm damages

Objective of Protection Works

- stabilize shoreline from future erosion
- limit storm wave uprush and damage
- provide recreational beach

Recommendations

- vertical seawalls and retaining walls are not recommended
- engineered rubblemound revetment is the recommended approach to protect shoreline from erosion; supplement or replace existing seawalls with sloping rubblemound revetments
- revetment design must consider beach stability and erosion (downcutting) of the nearshore lakebottom
- for more detailed information and guidance, refer to the supporting document entitled Design Considerations for Shore Protection Structures (Baird, 1992), and MNR(1986) and USACOE (1977, 1981)

Management Area Delineation

- Shoreline Area 1 - between the water's edge and a line defined by the 100 year flood line plus a 15 metre wave uprush allowance (Flood Hazard Limit)
- Shoreline Area 2 - between Shoreline Area 1 and a line defined by a 30 metre erosion allowance measured from the top of the bluff/bank (Erosion Hazard Limit)

Lambert Ln-Passingham Dr

Legend

- Shoreline Area 1
- Shoreline Area 2

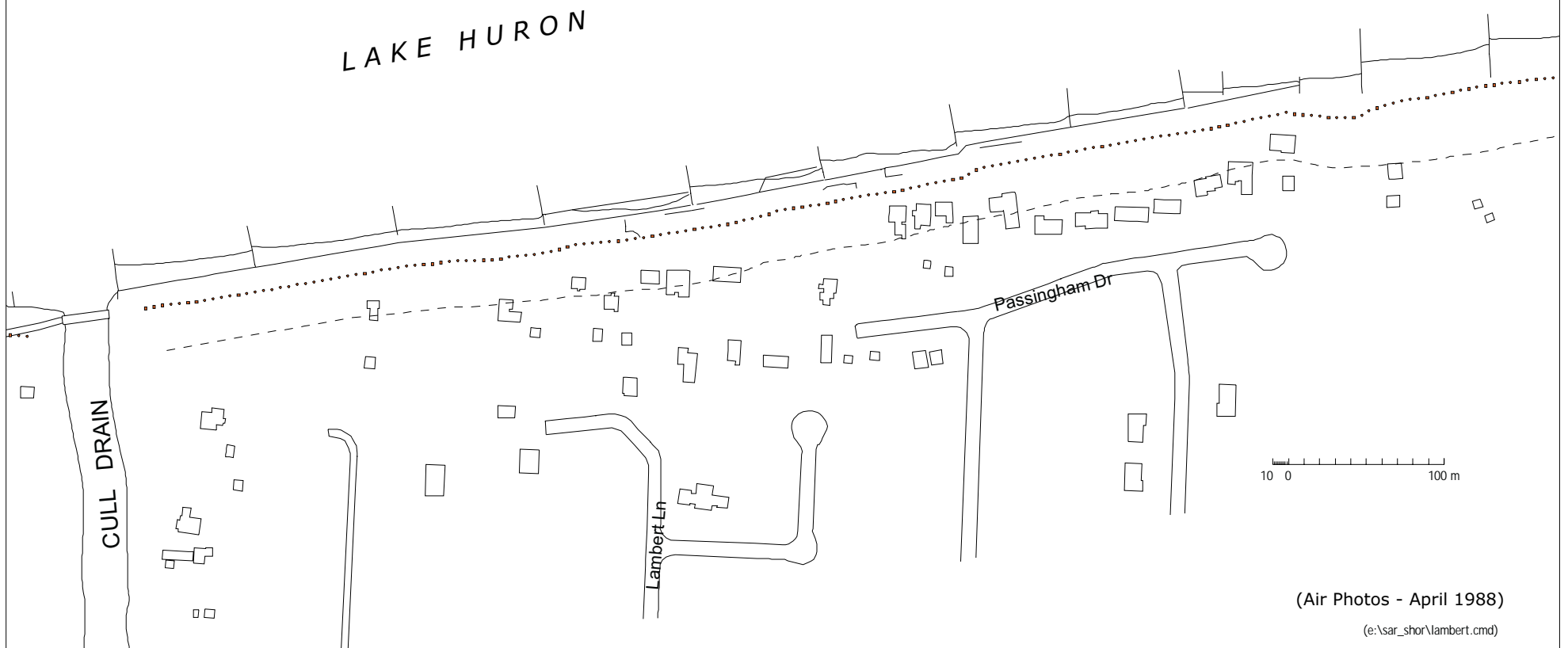


Figure 17

OLD LAKESHORE ROAD

(Elprado Street to Kenwick Street)
City of Sarnia (formerly Town of Clearwater)

Map Sheet #12 (Measurement Numbers 300-321)

Shoreline Characteristics

- beach - sand and gravel beach typically very narrow at normal summer water levels
 - no beach present during periods of higher lake levels
- bluff - grass covered bank; slope materials made up of poorly draining clay fill
- development
 - municipal road allowance contains shoreline bank and paved roadway
 - permanent residential development located south of road allowance
- protection works
 - vertical steel sheet-pile seawall and groynes replaced with engineered sloping rubblemound revetment between 1989 and 1992
 - groynes badly damaged by abrasion and ice loading

Erosion Issues

- long term top of bank recession rate is generally < 0.3 metres/year
- beach erosion and wave uprush damage
- historical damages to protection works, municipal infrastructure and property during high magnitude storm events
- with the absence of beach materials, the nearshore lakebottom is exposed to erosion (downcutting); as the nearshore becomes progressively deeper, the shoreline is exposed to increasingly severe wave attack and potential storm damages

Objective of Protection Works

- stabilize shoreline from future erosion
- limit storm wave uprush and damage
- provide recreational beach

Recommendations

- vertical seawalls and retaining walls are not recommended
- engineered rubblemound revetment is the recommended approach to protect shoreline from erosion; revetment design must consider beach stability and erosion (downcutting) of the nearshore lakebottom
- monitor condition of protection works, maintain structures and reconstruct where necessary
- alternative approach to protect shoreline (and incorporate a recreational beach) would require offshore breakwaters to contain beach fill; primary design issue would be maintaining longshore transport of sand past the project

Management Area Delineation

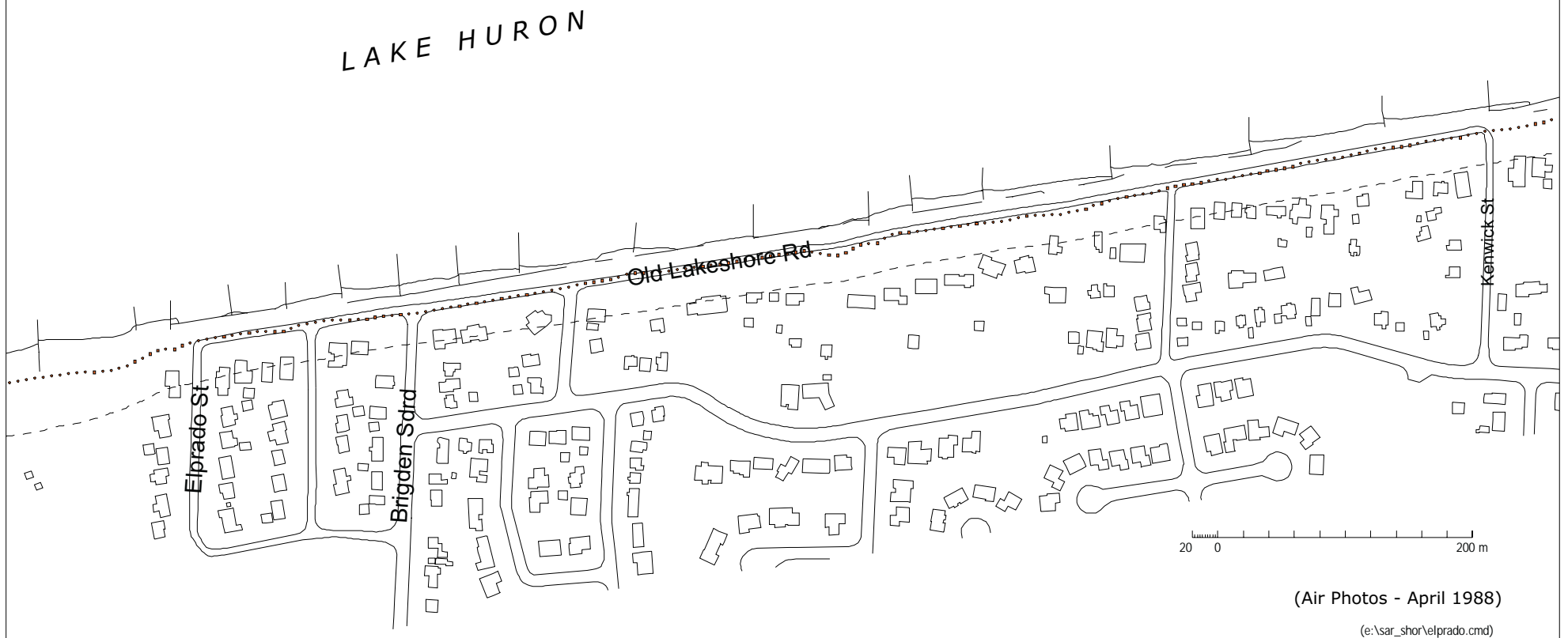
- Shoreline Area 1 - between the water's edge and a line defined by the 100 year flood line plus a 15 metre wave uprush allowance (Flood Hazard Limit)
- Shoreline Area 2 - between Shoreline Area 1 and a line defined by a 30 metre erosion allowance measured from the top of the bluff/bank (Erosion Hazard Limit)

Old Lakeshore Road

(Elprado Street to Kenwick Street)

Legend

- Shoreline Area 1
- Shoreline Area 2



(Air Photos - April 1988)

(e:\sar_shor\elprado.cmd)

Figure 18

WILDWOOD PARK - WESTGATE CRESCENT

City of Sarnia (formerly Town of Clearwater)

Map Sheets #12 and #13

Shoreline Characteristics

- beach - sand and gravel beach typically very narrow at normal summer water levels
 - no beach present during periods of higher lake levels
- bluff - grass covered bank; slope materials made up of poorly draining clay fill; broken concrete and fill dumped over bank to replace eroded slope
- development
 - municipal road allowance contains shoreline bank and paved walkway
 - permanent residential development located south of walkway on Westgate Crescent; Wildwood Park under municipal ownership
- protection works
 - vertical steel sheet-pile seawall and groynes; seawall along park replaced with sloping rubblemound revetment
 - groynes badly damaged by abrasion and ice loading
 - remaining seawall has collapsed in several areas

Erosion Issues

- long term top of bank recession rate is generally < 0.3 metres/year
- beach erosion and wave uprush damage
- historical damages to protection works, municipal infrastructure and property during high magnitude storm events
- with the absence of beach materials, the nearshore lakebottom is exposed to erosion (downcutting); as the nearshore becomes progressively deeper, the shoreline is exposed to increasingly severe wave attack and potential storm damages

Objective of Protection Works

- stabilize shoreline from future erosion
- limit storm wave uprush and damage
- provide recreational beach

Recommendations

- vertical seawalls and retaining walls are not recommended
- engineered rubblemound revetment is the recommended approach to protect shoreline from erosion; revetment design must consider beach stability and erosion (downcutting) of the nearshore lakebottom
- monitor condition of protection works, maintain structures and reconstruct where necessary
- alternative approach to protect shoreline (and incorporate a recreational beach) would require offshore breakwaters to contain beach fill; primary design issue would be maintaining longshore transport of sand past the project

Management Area Delineation

- Shoreline Area 1 - between the water's edge and a line defined by the 100 year flood line plus a 15 metre wave uprush allowance (Flood Hazard Limit)
- Shoreline Area 2 - between Shoreline Area 1 and a line defined by a 30 metre erosion allowance measured from the top of the bluff/bank (Erosion Hazard Limit)

Wildwood Park-Westgate Cres

Legend

- Shoreline Area 1
- Shoreline Area 2



(Air Photos - April 1988)

(e:\sar_shor\westgate.cmd)

Figure 19

OLD LAKESHORE ROAD

(Helen Avenue to Cow Creek)

City of Sarnia (formerly Town of Clearwater)

Map Sheet #13

Shoreline Characteristics

- beach - sand and gravel beach \pm 5 metres wide at normal summer water levels
 - no beach present during periods of higher lake levels
- bluff - grass covered bank; slope materials made up of poorly draining clay fill
- development
 - municipal road allowance contains shoreline bank and paved roadway
 - permanent residential development located south of road allowance
- protection works
 - vertical steel sheet-pile seawall and groynes being replaced with engineered sloping rubblemound revetment (approximately 600 metres completed to 1995)
 - groynes badly damaged by abrasion and ice loading

Erosion Issues

- long term top of bank recession rate is generally $<$ 0.3 metres/year
- beach erosion and wave uprush damage
- historical damages to protection works, municipal infrastructure and property during high magnitude storm events
- with the absence of beach materials, the nearshore lakebottom is exposed to erosion (downcutting); as the nearshore becomes progressively deeper, the shoreline is exposed to increasingly severe wave attack and potential storm damages

Objective of Protection Works

- stabilize shoreline from future erosion
- limit storm wave uprush and damage
- provide recreational beach

Recommendations

- vertical seawalls and retaining walls are not recommended
- engineered rubblemound revetment is the recommended approach to protect shoreline from erosion; revetment design must consider beach stability and erosion (downcutting) of the nearshore lakebottom
- monitor condition of protection works, maintain structures and reconstruct where necessary
- alternative approach to protect shoreline (and incorporate a recreational beach) would require offshore breakwaters to contain beach fill; primary design issue would be maintaining longshore transport of sand past the project

Management Area Delineation

- Shoreline Area 1 - between the water's edge and a line defined by the 100 year flood line plus a 15 metre wave uprush allowance (Flood Hazard Limit)
- Shoreline Area 2 - between Shoreline Area 1 and a line defined by a 30 metre erosion allowance measured from the top of the bluff/bank (Erosion Hazard Limit)

Old Lakeshore Road (Helen Avenue to Cow Creek)

Legend

- Shoreline Area 1
- Shoreline Area 2

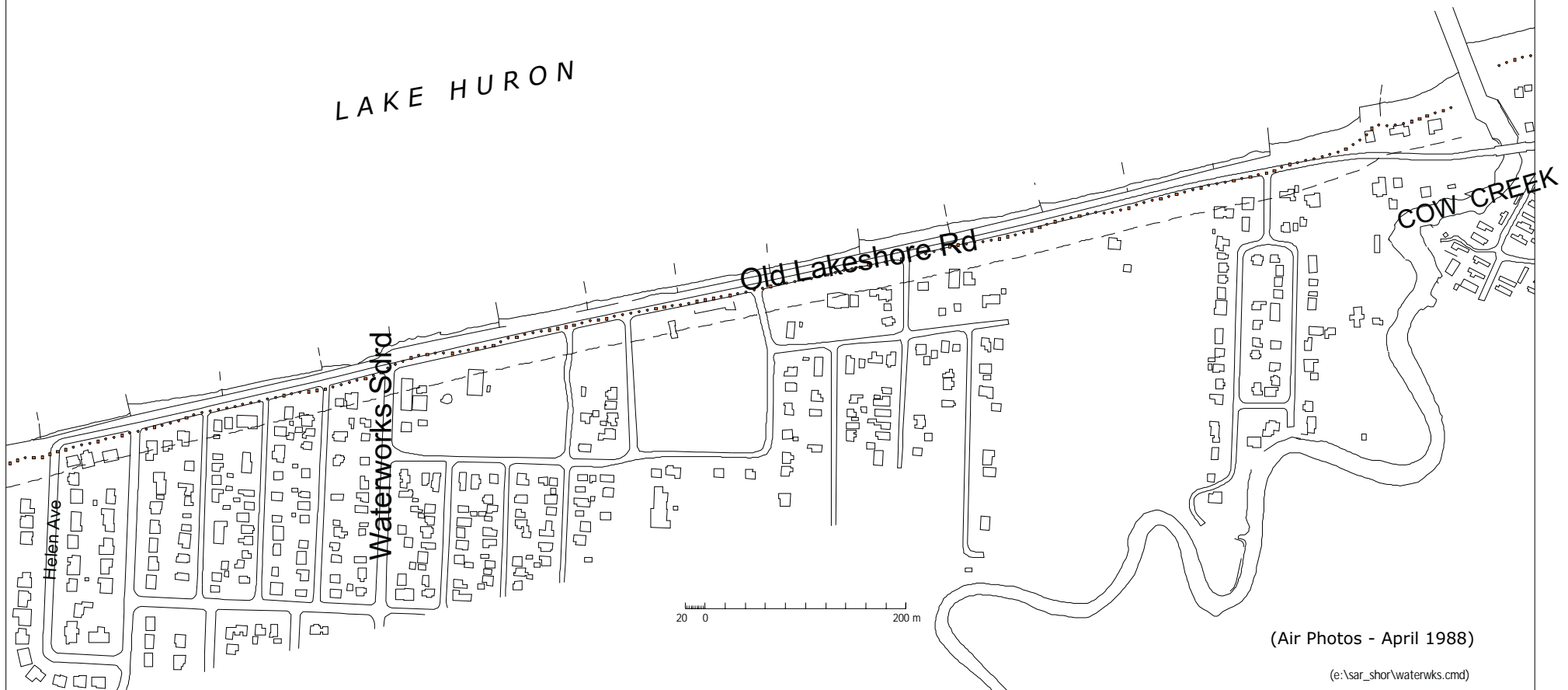


Figure 20

SUNET BOULEVARD - LAKEVIEW TRAIL

City of Sarnia (formerly Town of Clearwater)

Map Sheets #13 and #14 (Measurement Numbers -381)

Shoreline Characteristics

- beach - sand beach typically \pm 10-15 metres wide at normal summer water levels, becoming narrower during periods of high lake levels
- bluff - low bluff; well vegetated with mature trees
- development
 - permanent residential development interspersed with some cottage residences
 - dwellings located along the top of bluff
- protection works
 - steel sheet-pile groynes; some groynes supplemented with vertical sheet-pile seawalls and retaining walls
 - training walls (jetties) at mouth of Cow Creek function as long groynes and act to stabilize the recreational beach to the east for approximately 600 metres
 - Cow Creek training walls administered by Small Craft Harbours, Fisheries and Oceans Canada

Erosion Issues

- long term top of bank recession rate is generally $<$ 0.3 metres/year
- beach erosion and wave uprush damage
- historical damages to protection works and property during high magnitude storm events
- turbulence created by wave reflection off vertical seawalls and groynes may contribute to removal of beach materials
- during storm events, wave action can temporarily overrun the beach and directly attack the shoreline bluff and protection works

Objective of Protection Works

- limit storm wave uprush and damage
- provide recreational beach

Recommendations

- vertical seawalls and retaining walls are not recommended
- supplement or replace existing vertical seawalls with sloping rubblemound revetments to reduce wave impact and beach erosion
- maintain existing groynes; during periods of high lake levels, "nourish" existing groyne cells with suitable beach sand (clean sand and gravel, $D_{50} > 0.3\text{mm}$)
- for more detailed information and guidance, refer to the supporting document entitled Design Considerations for Shore Protection Structures (Baird, 1992), and MNR(1986) and USACOE (1977, 1981)

Management Area Delineation

- Shoreline Area 1 - between the water's edge and a line defined by the 100 year flood line plus a 15 metre wave uprush allowance (Flood Hazard Limit)
- Shoreline Area 2 - between Shoreline Area 1 and a line defined by the Flood Hazard Limit plus a 30 metre erosion allowance

Sunset Blvd-Lakeview Tr

Legend

- Shoreline Area 1
- Shoreline Area 2

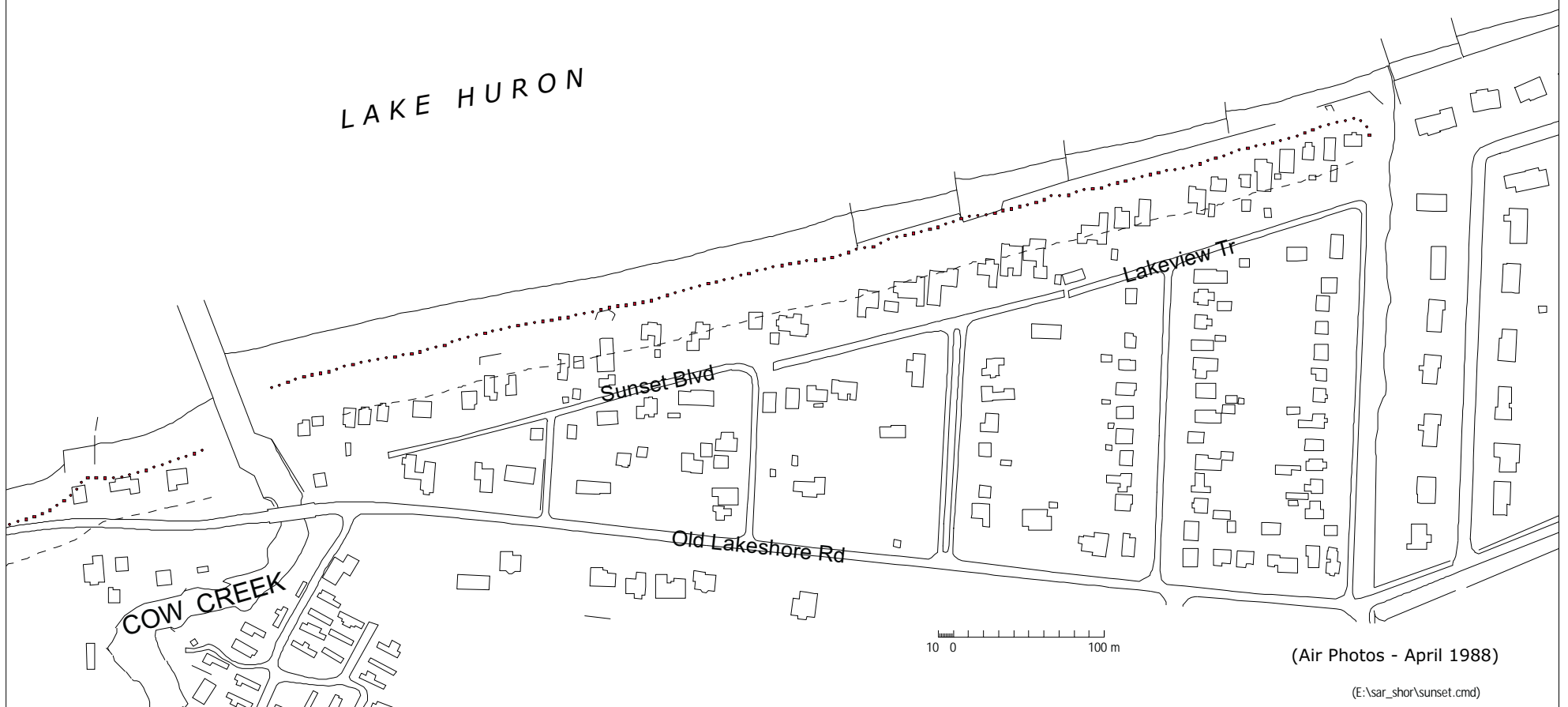


Figure 21

SANDPIPER TRAIL - LAKE VIEW AVENUE - WELLINGTON BEACH - DEVONSHIRE ROAD

(Registered Plan 12, 14, 16, 13, 20, 495, and 19)

Plympton Township

Map Sheets #14 and #15 (Measurement Numbers 382-420)

Shoreline Characteristics

- beach - sand beach typically \pm 5 metres wide at normal summer water levels, becoming narrow or non-existent during periods of high lake levels
- bluff - high bluff; stabilization measures (grading, drainage) undertaken in some areas; steep and eroding with sparse vegetation in other areas
- development - permanent residential development with some cottage residences
- dwellings located at top of bluff
- protection works - steel sheet pile groynes; most groynes supplemented with vertical sheet pile seawalls and retaining walls; at two locations groynes have been constructed with "T" and "L" shaped heads

Erosion Issues

- long term bluff recession rate is generally $<$ 0.3 metres/year
- beach erosion and wave uprush damage during storm events and high lake level periods
- turbulence created by wave reflection off vertical seawalls and groynes may remove beach materials exposing the protection works to more severe wave attack
- historical damage to protection works and property during high magnitude storm events

Objective of Protection Works

- limit storm wave uprush and damage
- provide recreational beach

Recommendations

- vertical seawalls and retaining walls are not recommended
- supplement or replace existing vertical seawalls with sloping rubblemound revetments to reduce wave impact and beach erosion
- revetment design must consider beach stability and erosion (downcutting) of the nearshore lake bottom
- maintain existing groynes; where groyne cells are not full "nourish" with suitable beach sand (clean sand and gravel, $D_{50} > 0.3\text{mm}$)
- the T shaped groynes are meant to reduce turbulence and scour within the groyne cell; constructed in deeper water, they tend to be more exposed to damages caused by wave impact and ice
- for more detailed information and guidance, refer to the supporting document entitled Design Considerations for Shore Protection Structures (Baird, 1992), and, MNR (1986) and USA COE (1977, 1981)

Management Area Delineation

- Shoreline Area 1 - between the water's edge and a line defined by the slope stability allowance measured landward from the toe of the bluff
- Shoreline Area 2 - between Shoreline Area 1 and a line defined by a 30 metre erosion allowance measured from the top of the bluff (Erosion Hazard Limit)

Sandpiper Trail and Lake View Avenue

Legend

- Shoreline Area 1
- Shoreline Area 2

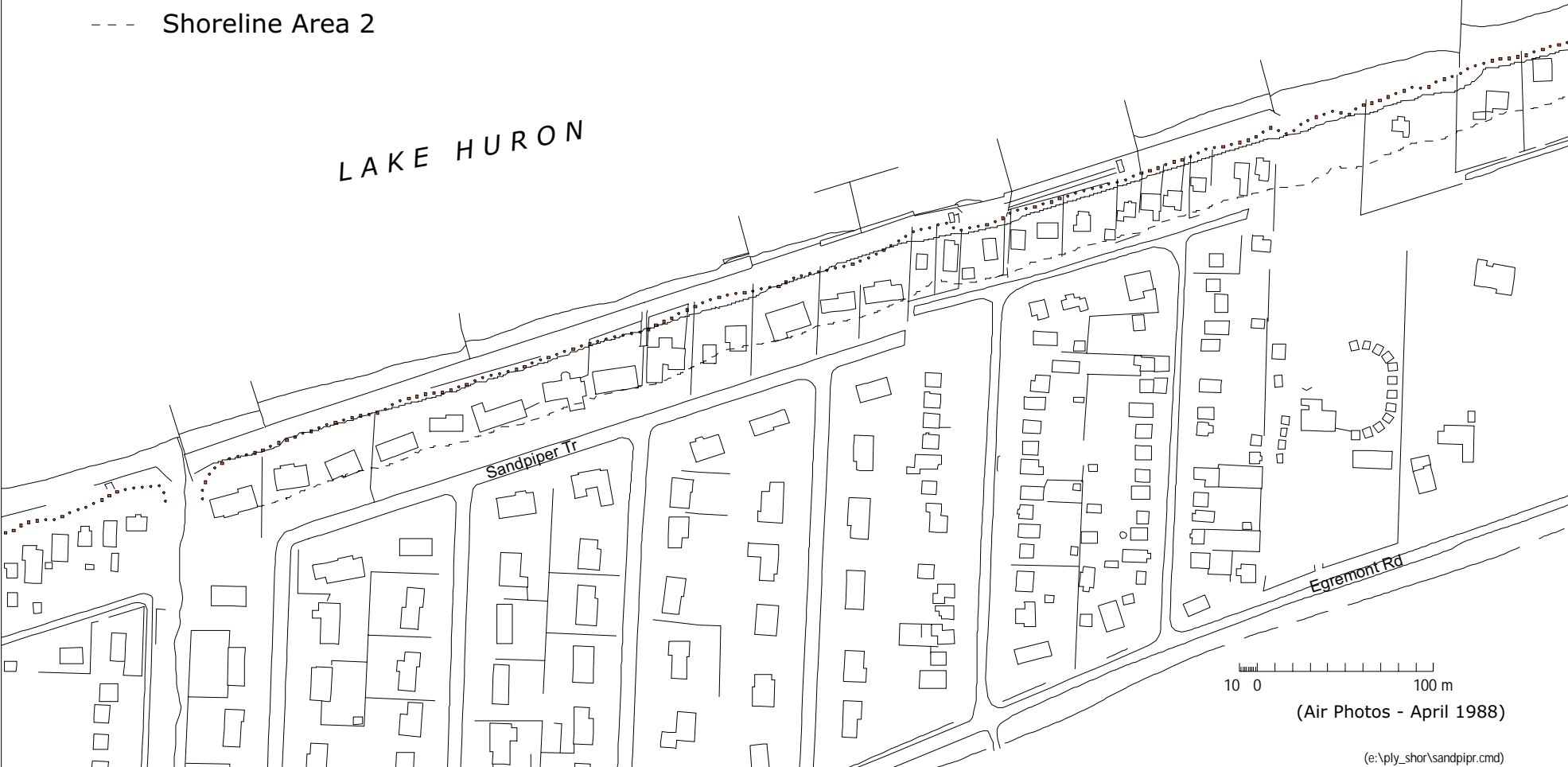


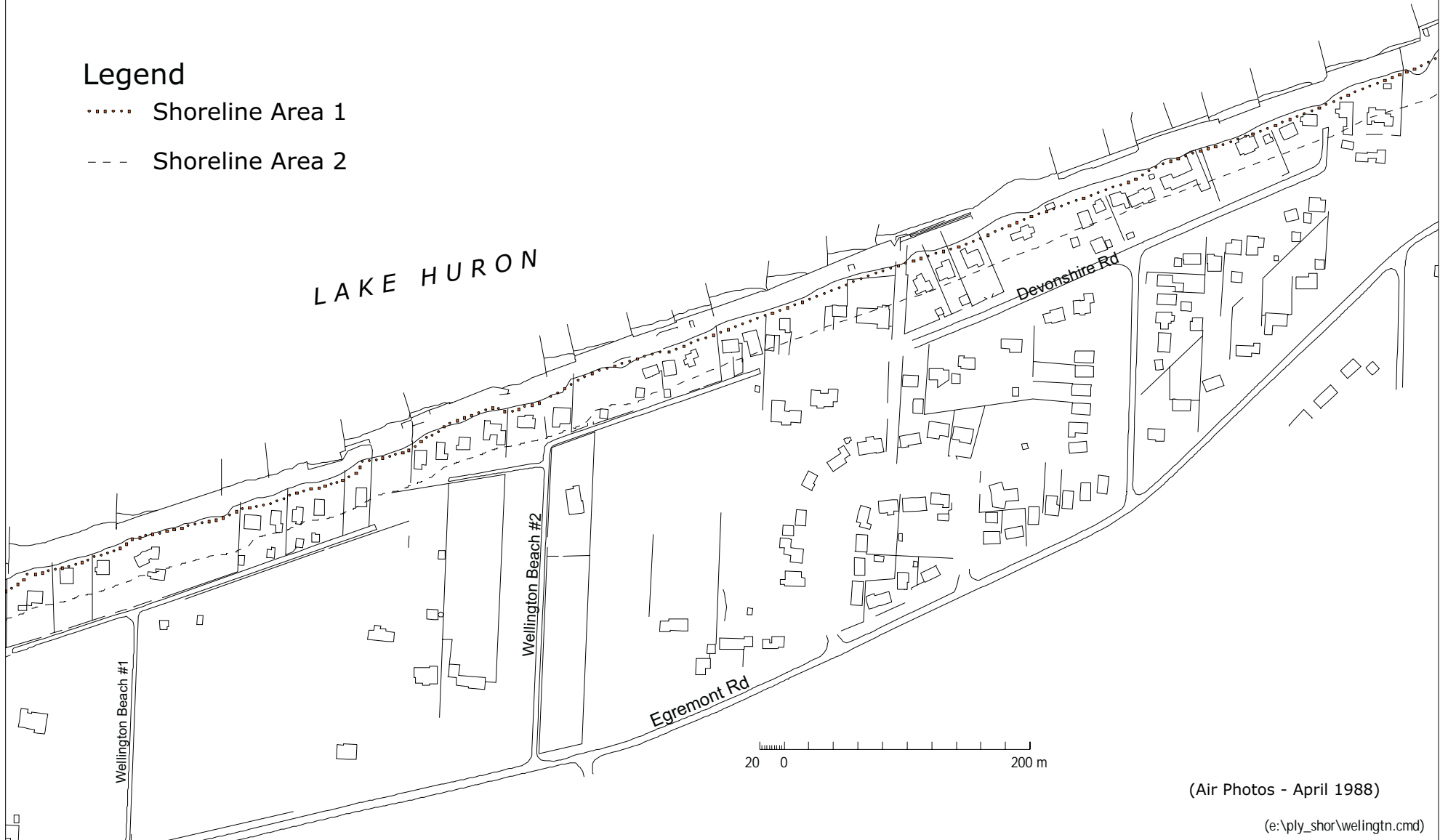
Figure 22

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Wellington Beaches and Devonshire Road

Legend

- Shoreline Area 1
- Shoreline Area 2



(Air Photos - April 1988)

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Figure 23

LOTS 10 to 13, Front Concession

(Egremont Road)
Plympton Township

Map Sheet # 15 (Measurement Numbers 422-436)

Shoreline Characteristics

- beach - sand beach typically \pm 5 metres wide at normal summer water levels, becoming narrow or non-existent during periods of high lake levels
- bluff - high bluff; stabilization measures (grading, drainage) undertaken in some areas; steep and eroding with sparse vegetation in other areas
- development
 - permanent residential development
 - dwellings located at top of bluff
- protection works - steel sheet pile groynes; most groynes supplemented with vertical sheet pile seawalls

Erosion Issues

- long term recession rate is generally $<$ 0.3 metres/year
- beach erosion and wave uprush damage during storm events and high lake level periods
- turbulence created by wave reflection off vertical seawalls and groynes may remove beach materials exposing the protection works to more severe wave attack
- historical damage to protection works and property during high magnitude storm events

Objective of Protection Works

- limit storm wave uprush and damage
- provide recreational beach

Recommendations

- vertical seawalls and retaining walls are not recommended
- supplement or replace existing vertical seawalls with sloping rubblemound revetments to reduce wave impact and beach erosion
- revetment design must consider beach stability and erosion (downcutting) of the nearshore lake bottom
- maintain existing groynes; where groyne cells are not full "nourish" with suitable beach sand (clean sand and gravel, $D_{50} > 0.3\text{mm}$)
- for more detailed information and guidance, refer to the supporting document entitled Design Considerations for Shore Protection Structures (Baird, 1992), and, MNR (1986) and USA COE (1977, 1981)

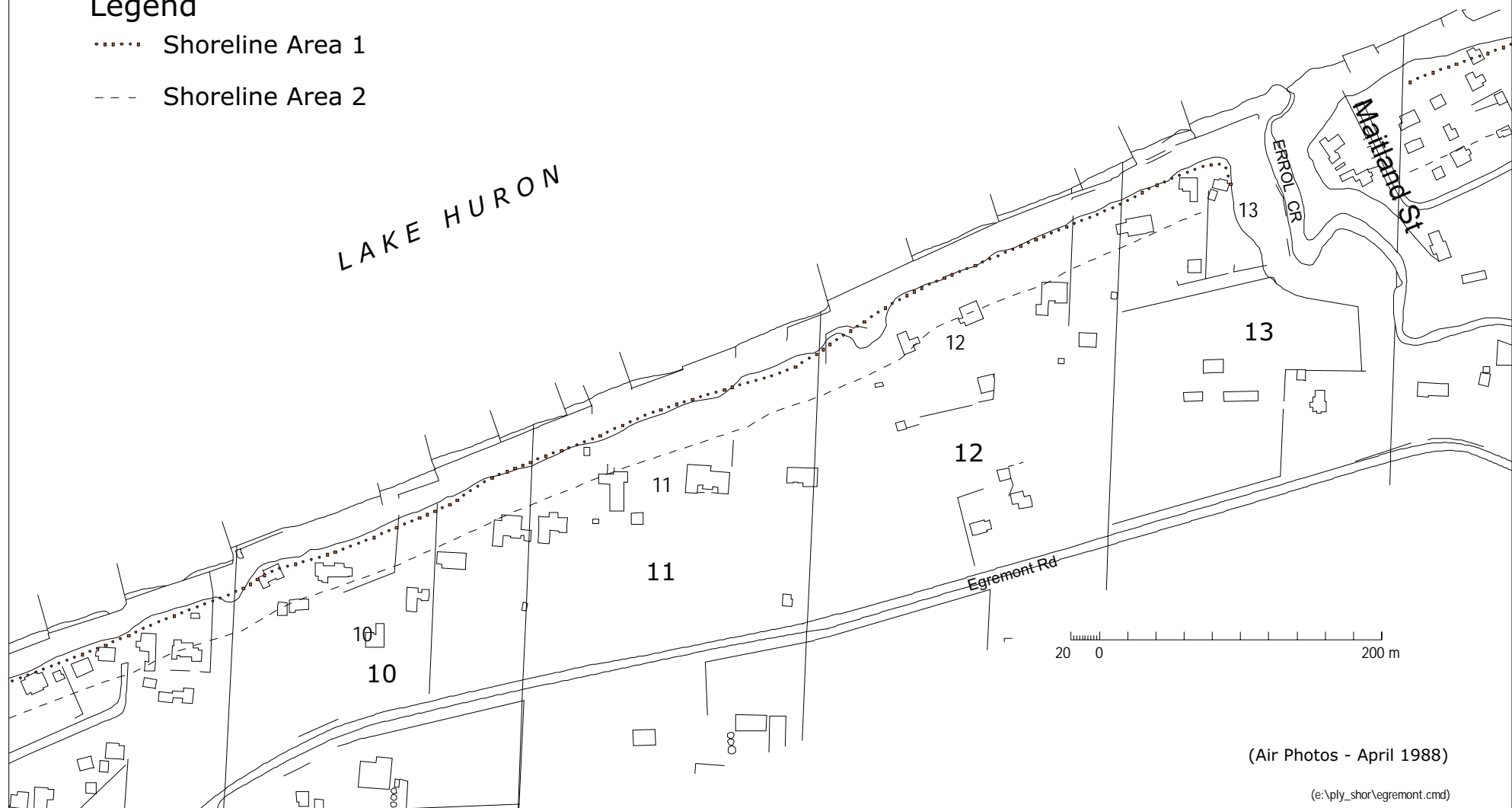
Management Area Delineation

- Shoreline Area 1 - between the water's edge and a line defined by the slope stability allowance measured landward from the toe of the bluff
- Shoreline Area 2 - between Shoreline Area 1 and a line defined by a 30 metre erosion allowance measured from the top of the bluff (Erosion Hazard Limit)

Lots 10 to 13, Front Concession

Legend

- Shoreline Area 1
- Shoreline Area 2



(Air Photos - April 1988)

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Figure 24

ERROL BEACH and SUBDIVISION

(Registered Plans 2 and 421)

Plympton Township

Map Sheets #14 and #15 (Measurement Numbers 439-460)

Shoreline Characteristics

- beach - sand beach typically \pm 10 metres wide at normal summer water levels, becoming narrower during periods of high lake levels
- bluff - high bluff; stabilization measures (grading, drainage) undertaken in some areas; steep and eroding with sparse vegetation in other areas
- development
 - permanent residential development
 - dwellings located at top of bluff
- protection works - steel sheet pile groynes; some groynes supplemented with vertical sheet pile seawalls

Erosion Issues

- long term recession rate is generally high at $>$ 0.5 metres/year
- beach erosion and wave uprush damage
- during storm events, wave action can temporarily overrun the beach and directly attack the bluff materials and protection works
- turbulence created by wave reflection off vertical seawalls and groynes may remove beach materials exposing the protection works to more severe wave attack
- historical damage to protection works and property during high magnitude storm events

Objective of Protection Works

- stabilize shoreline from future recession
- limit storm wave uprush and damage
- provide recreational beach

Recommendations

- community approach to construction and maintenance of protection works is recommended
- vertical seawalls and retaining walls are not recommended
- supplement or replace existing vertical seawalls with sloping rubblemound revetments to reduce wave impact and beach erosion
- revetment design must consider beach stability and erosion (downcutting) of the nearshore lake bottom
- maintain existing groynes; where groyne cells are not full "nourish" with suitable beach sand (clean sand and gravel, $D_{50} >$ 0.3mm)
- for more detailed information, refer to the supporting document entitled Design Considerations for Shore Protection Structures (Baird, 1992), and, MNR (1986) and USACOE (1977, 1981)

Management Area Delineation

- Shoreline Area 1 - between the water's edge and a line defined by the slope stability allowance measured landward from the toe of the bluff
- Shoreline Area 2 - between Shoreline Area 1 and a line defined by the slope stability allowance plus 100 times the average annual recession rate (Erosion Hazard Limit)

Errol Beach and Subdivision

Legend

- Shoreline Area 1
- Shoreline Area 2

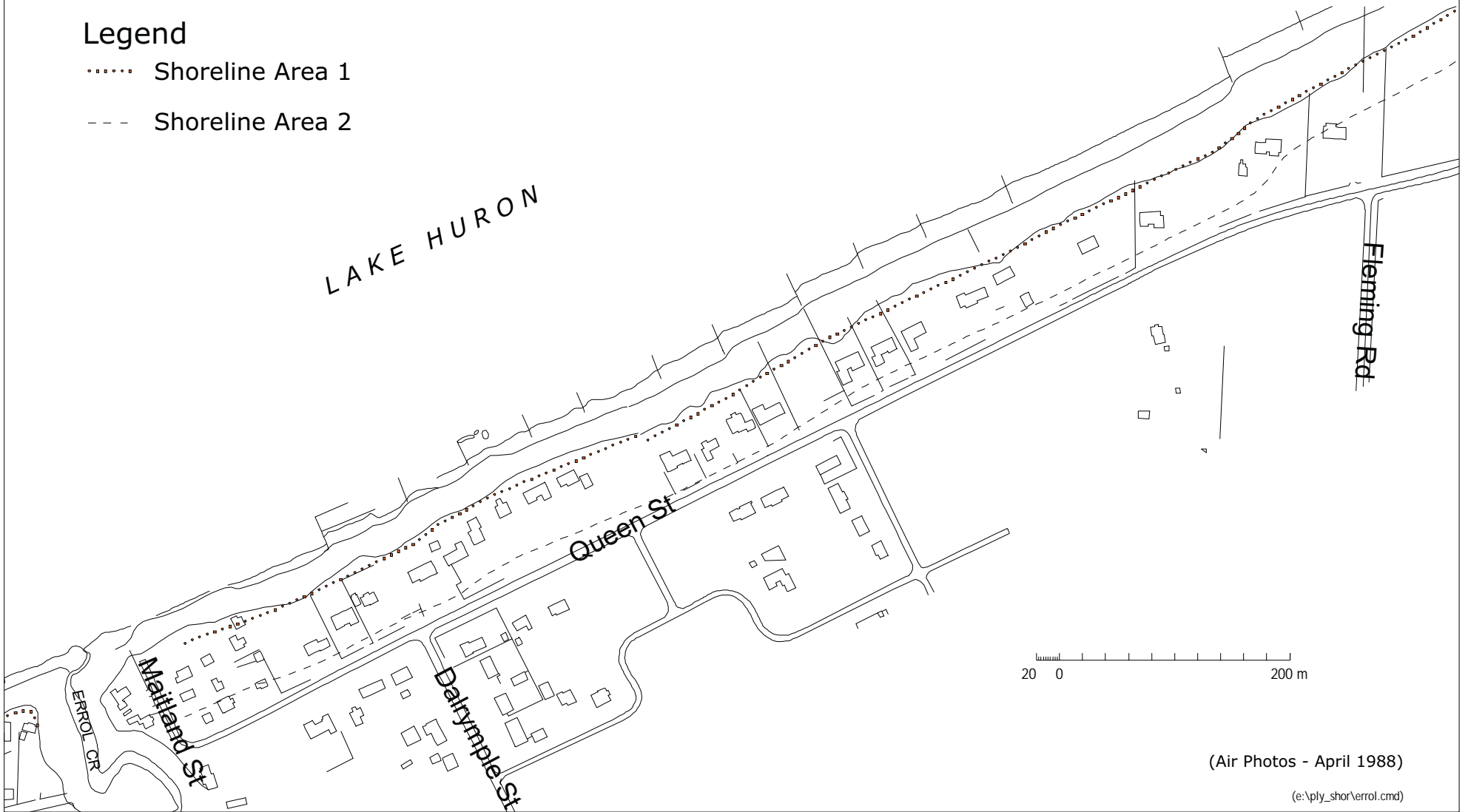


Figure 25

BEVERLY GLEN
(Registered Plan 30)
Plympton Township

Map Sheet # 16 (Measurement Numbers 684-688)

Shoreline Characteristics

- beach - sand beach typically \pm 10 metres wide at normal summer water levels, becoming narrow during periods of high lake levels
- bluff - high bluff; areas sparsely vegetated with seasonal grasses, small trees and shrubs; other areas well vegetated with mature trees
- development - permanent residential development
- dwellings located along the top of bluff
- protection works - steel sheet pile groynes; supplemented at one location with gabion basket seawall

Erosion Issues

- long term recession rate is generally $>$ 0.5 metres/year
- undercutting at the toe of the bluff by wave action has caused instability and successive shallow slips on the bluff face
- during storm events, wave action can temporarily overrun the beach and directly attack the bluff materials
- wave uprush during storm events is intensified during periods of high lake levels
- instability aggravated by landside influences (drainage, groundwater seepage, etc.)

Objective of Protection Works

- stabilize shoreline from future recession
- limit storm wave uprush damages
- provide recreational beach

Recommendations

- community approach to construction and maintenance of protection works is recommended
- vertical seawalls and retaining walls are not recommended
- maintain existing groynes; where groyne cells are not full, "nourish" existing groyne cells with suitable beach sand (clean sand and gravel, $D_{50} > 0.3\text{mm}$)
- intercept surface runoff and convey down bluff to beach in closed drainage system
- where additional protection of toe of bluff is required, sloping rubblemound revetment constructed along toe of bluff is recommended approach to protect shoreline from erosion
- for more detailed information and guidance, refer to the supporting document entitled Design Considerations for Shore Protection Structures (Baird, 1992), and, MNR (1986) and USA COE (1977, 1981)

Management Area Delineation

- Shoreline Area 1 - between the water's edge and a line defined by the slope stability allowance measured landward from the toe of the bluff
- Shoreline Area 2 - between Shoreline Area 1 and a line defined by the slope stability allowance plus 100 times the average annual recession rate (Erosion Hazard Limit)

Beverly Glen

Legend

- Shoreline Area 1
- Shoreline Area 2

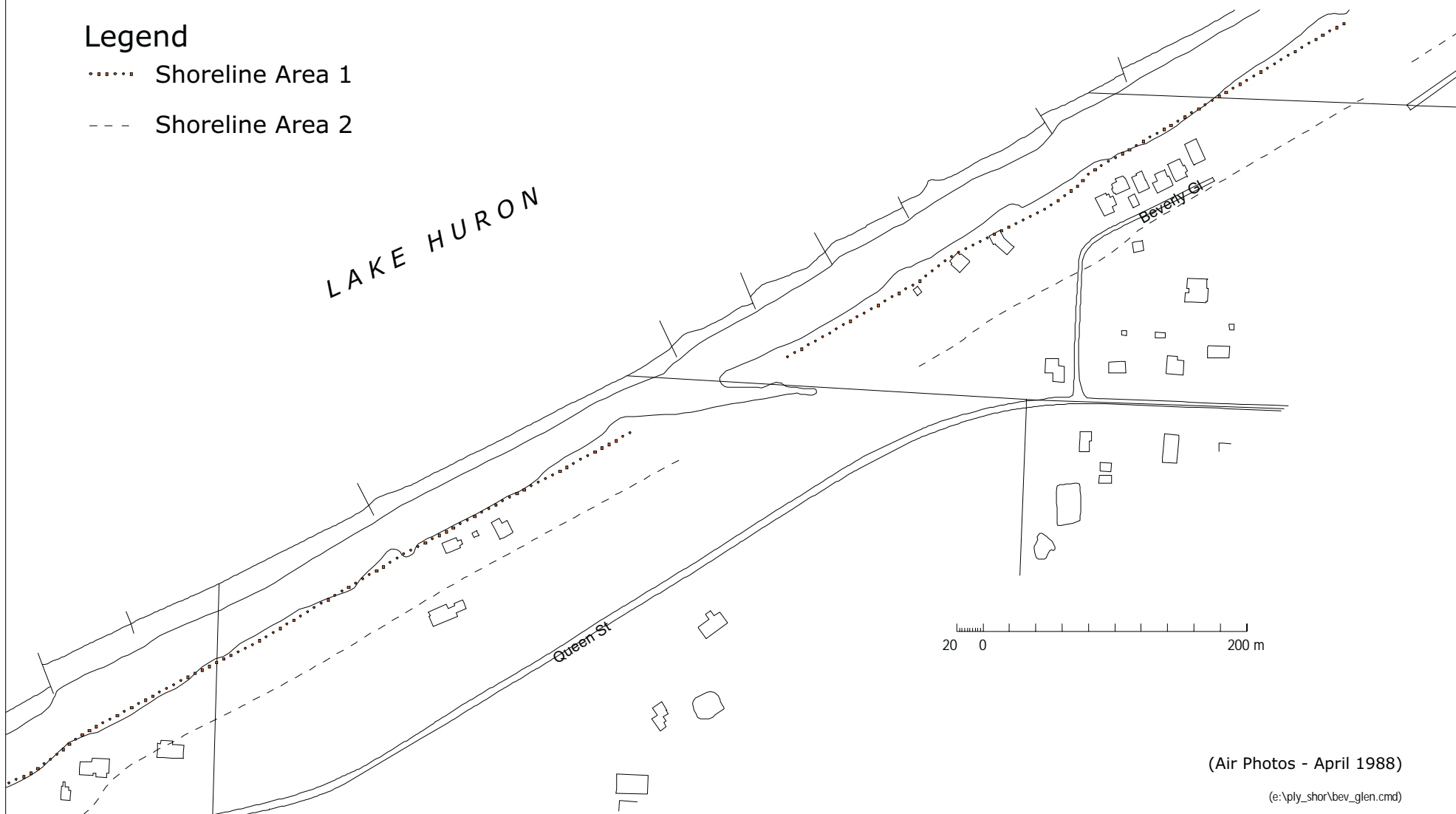


Figure 26

(Air Photos - April 1988)

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FERNE AVENUE
(Registered Plan 496)
Plympton Township

Map Sheets #16 and #17 (Measurement Numbers 484-497)

Shoreline Characteristics

- beach - sand beach typically \pm 5 metres wide at normal summer water levels, becoming narrow or non-existent during periods of high lake levels
- bluff - high bluff; steep and eroding; sparsely vegetated with seasonal grasses and some small shrubs
- development - 22 vacant lots in registered plan dated 1960
- protection works - shoreline bluff unprotected

Erosion Issues

- long term recession rate is generally $>$ 0.3 metres/year
- undercutting at the toe of the bluff by wave action has caused instability and successive shallow slips on the bluff face but also deeper internal rotational slumps
- wave uprush during storm events is intensified during periods of high lake levels
- instability aggravated by landside influences (drainage, groundwater seepage, loading, etc.)

Objective of Protection Works

- stabilize shoreline from future recession

Recommendations

- engineered sloping rubblemound revetment constructed along toe of bluff is recommended approach to protect shoreline from erosion; bluff stabilization measures (grading, drainage, vegetation) also necessary above protection works
- **CONSTRUCT PRIOR TO DEVELOPMENT TO ENSURE ACCESS** and suitable setbacks
- revetment design must consider beach stability and erosion (downcutting) of the nearshore lake bottom
- any new groyne construction should include prefilling of groyne cells with suitable beach sand (clean sand and gravel, $D_{50} > 0.3\text{mm}$)
- for more detailed information and guidance, refer to the supporting document entitled Design Considerations for Shore Protection Structures (Baird, 1992), and, MNR (1986) and USA COE (1977, 1981)
- **as an alternative to protection works, recommend that the property owner(s) consider acquisition of additional land from adjacent owner to facilitate construction of dwellings landward of Shoreline Area 2 (Erosion Hazard Limit)**

Management Area Delineation

- Shoreline Area 1 - between the water's edge and a line defined by the slope stability allowance measured landward from the toe of the bluff
- Shoreline Area 2 - between Shoreline Area 1 and a line defined by the slope stability allowance plus 100 times the average annual recession rate (Erosion Hazard Limit)

Ferne Avenue

Legend

- Shoreline Area 1
- Shoreline Area 2

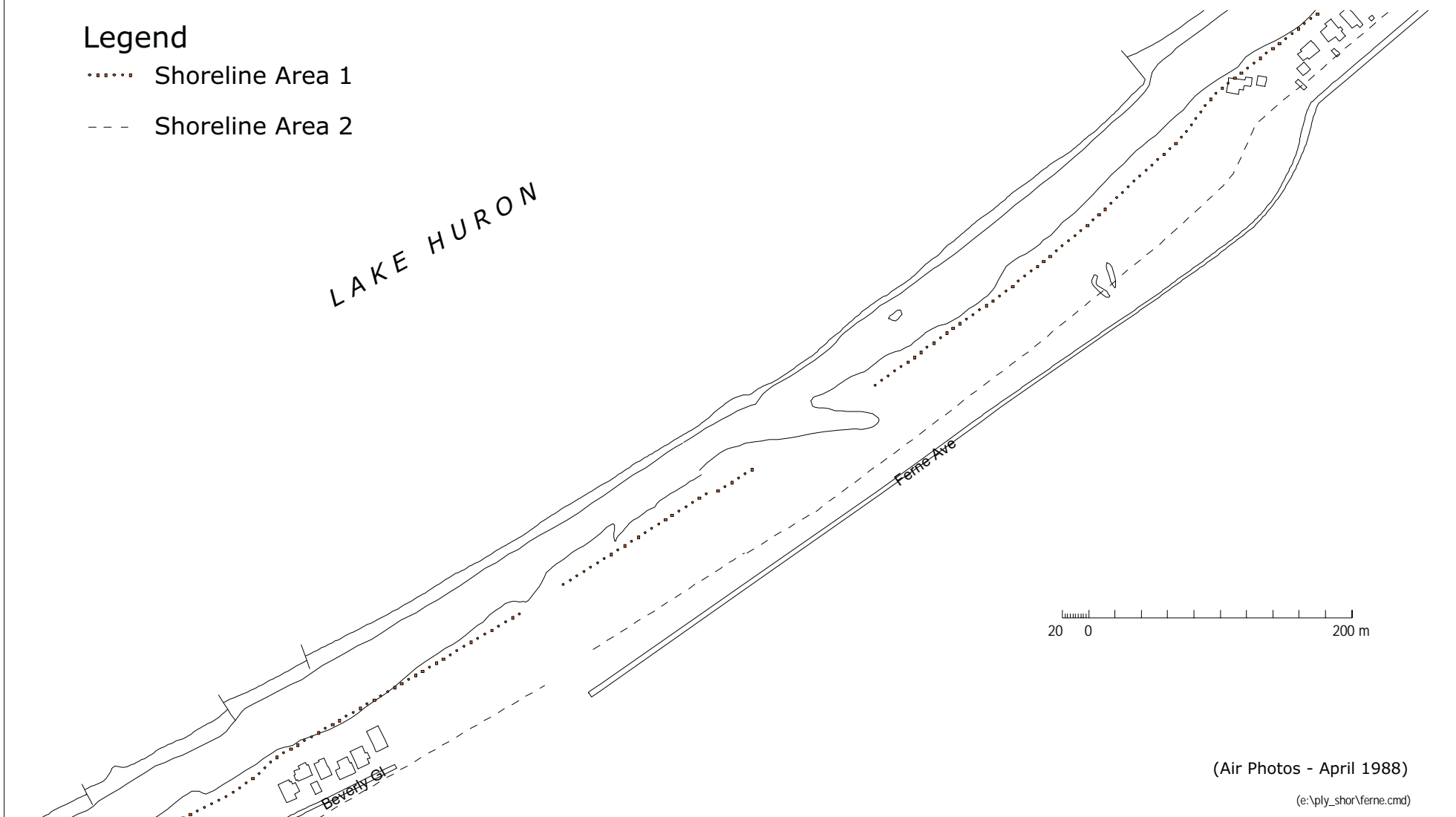


Figure 27

(Air Photos - April 1988)

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BONNIE DOON SUBDIVISION

(Registered Plan 29)

Plympton Township

Map Sheet #17 (Measurement Numbers 498-509)

Shoreline Characteristics

- beach - sand beach typically \pm 10 metres wide at normal summer water levels, becoming narrower during periods of high lake levels
- bluff - high bluff; sparsely vegetated with seasonal grasses and some small tree and shrubs
- development
 - permanent residential development with some cottage residences
 - dwellings located at top of bluff
- protection works
 - much of shoreline bluff unprotected
 - several steel sheet pile groynes irregularly spaced; one groyne supplemented with vertical sheet pile seawall/retaining wall

Erosion Issues

- long term recession rate is generally $>$ 0.3 metres/year
- undercutting at the toe of the bluff by wave action has caused instability and successive shallow slips on the bluff face but also deeper internal rotational slumps
- during storm events, wave action can temporarily overrun the beach and directly attack the bluff materials
- wave uprush during storm events is intensified during periods of high lake levels
- instability aggravated by landside influences (drainage, groundwater seepage, loading, etc.)

Objective of Protection Works

- stabilize shoreline from future recession
- limit storm wave uprush and damage
- provide recreational beach

Recommendations

- community approach to construction and maintenance of protection works is recommended
- vertical seawalls and retaining walls are not recommended
- engineered sloping rubblemound revetment constructed along toe of bluff is recommended approach to protect shoreline from erosion; bluff stabilization measures (grading, drainage, vegetation) also necessary above protection works; **revetment design must consider beach stability and erosion (downcutting) of the nearshore lake bottom**
- maintain existing groynes; where groyne cells are not full "nourish" with suitable beach sand (clean sand and gravel, $D_{50} >$ 0.3mm)
- for more detailed information, refer to the supporting document entitled Design Considerations for Shore Protection Structures (Baird, 1992), and, MNR (1986) and USACOE (1977, 1981)

Management Area Delineation

- Shoreline Area 1 - between the water's edge and a line defined by the slope stability allowance measured landward from the toe of the bluff
- Shoreline Area 2 - between Shoreline Area 1 and a line defined by the slope stability allowance plus 100 times the average annual recession rate (Erosion Hazard Limit)

Bonnie Doone Subdivision

Legend

- Shoreline Area 1
- Shoreline Area 2

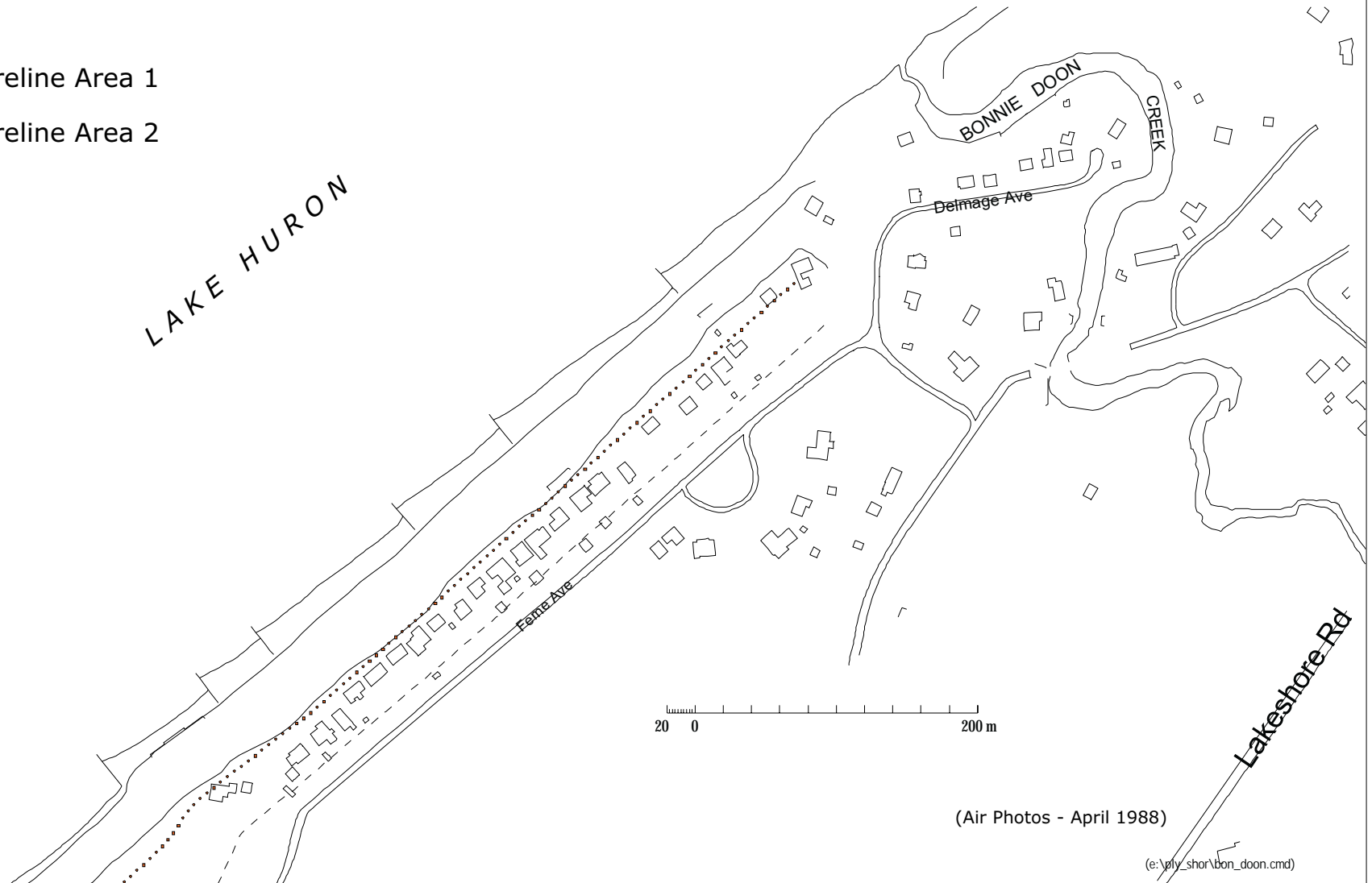


Figure 28

BALDWIN - POINT VIEW SUBDIVISIONS

(Registered Plans 587 and 33)
Plympton Township

Map Sheet #17 (Measurement Numbers 517-520)

Shoreline Characteristics

- beach - sand beach typically \pm 10 metres wide at normal summer water levels, becoming narrower during periods of high lake levels
- bluff - high bluff; well vegetated with mature trees
 - some localized instability (creep, slumping) due to previous toe erosion by wave action, and landside influences (drainage, groundwater seepage, etc.)
- development
 - seasonal and permanent residential development
 - dwellings located at top of bluff
- protection works - steel sheet pile groynes

Erosion Issues

- long term recession rate is generally low at < 0.3 metres/year
- during storm events, wave action can temporarily overrun the beach and directly attack the bluff materials; erosion of the beach and toe of bluff result

Objective of Protection Works

- limit storm wave uprush damages and toe of bluff erosion
- provide recreational beach

Recommendations

- community approach to construction and maintenance of protection works is recommended
- vertical seawalls and retaining walls are not recommended
- maintain existing groynes
- intercept surface runoff and convey down bluff to beach in closed drainage system
- if additional protection from wave uprush is required during periods of high lake levels, "nourish" existing groyne cells with suitable beach sand (clean sand and gravel, $D_{50} > 0.3\text{mm}$)
- where additional protection of toe of bluff is required and/or beach nourishment not feasible, construct sloping rubblemound revetment along toe of bluff to reduce wave impact and beach erosion
- for more detailed information and guidance, refer to the supporting document entitled Design Considerations for Shore Protection Structures (Baird, 1992), and, MNR (1986) and USA COE (1977, 1981)

Management Area Delineation

- Shoreline Area 1 - between the water's edge and a line defined by the slope stability allowance measured landward from the toe of the bluff
- Shoreline Area 2 - between Shoreline Area 1 and a line defined by a 30 metre erosion allowance measured from the top of the bluff (Erosion Hazard Limit)

Baldwin - Point View Subdivisions

Legend

- Shoreline Area 1
- Shoreline Area 2

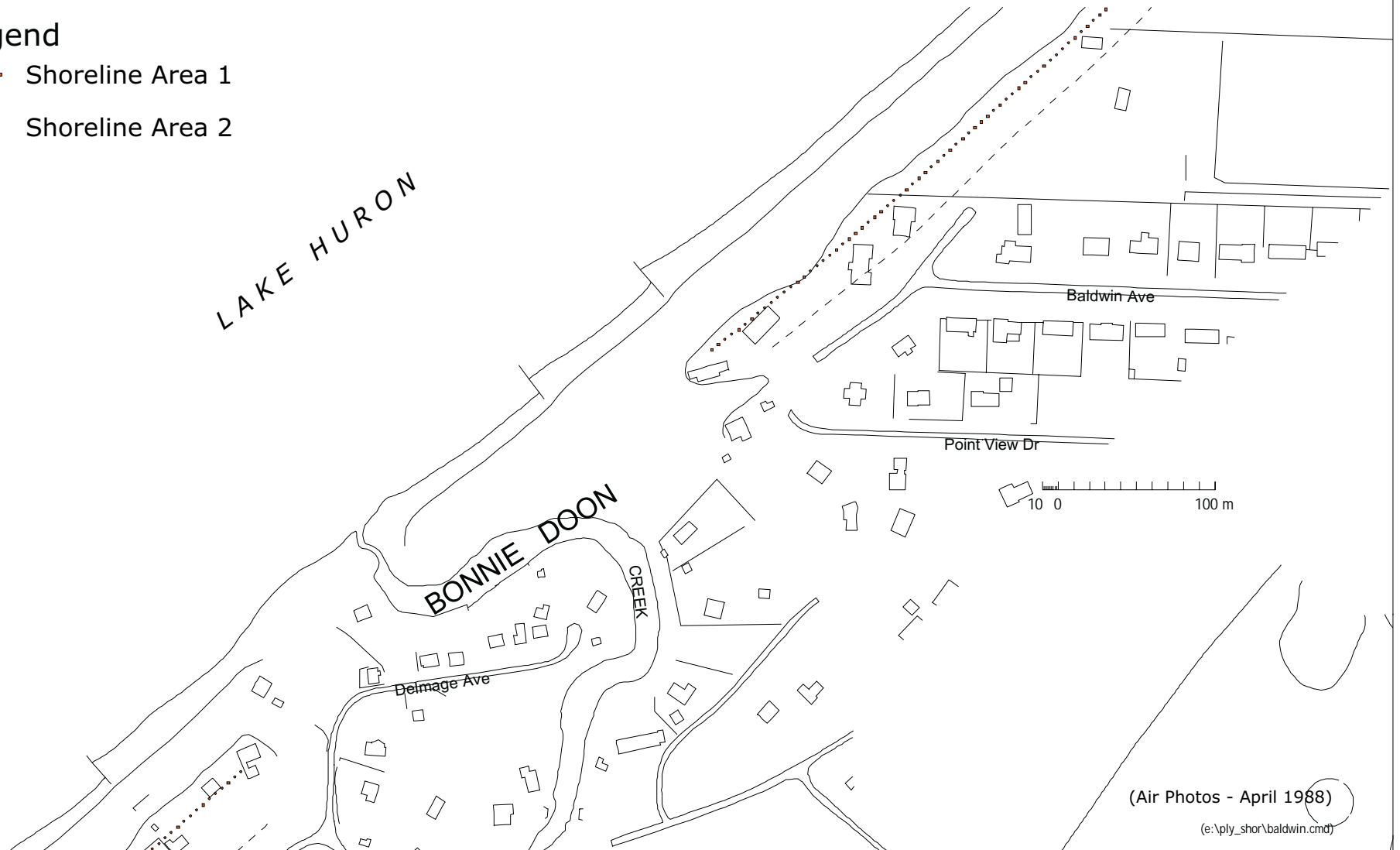


Figure 29

(Air Photos - April 1988)

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BLUE POINT BAY

(Lot 29, Front Concession)
Plympton Township

Map Sheet #18 (Measurement Numbers 541-544)

Shoreline Characteristics

- beach - sand and gravel beach typically \pm 10 metres wide at normal summer water levels, becoming narrow during periods of high lake levels
- bluff - high bluff; well vegetated with mature trees
 - some localized instability (creep, slumping) due to previous toe erosion by wave action, and landside influences (drainage, groundwater seepage, etc.)
 - gully development prevalent
- development
 - seasonal residential development
 - dwellings located along the top of bluff
- protection works - shoreline bluff unprotected

Erosion Issues

- long term recession rate is generally low at $<$ 0.3 metres/year
- beach erosion and toe of bluff erosion caused by wave uprush during storms and high lake level periods

Objective of Protection Works

- limit storm wave uprush damages and toe of bluff erosion

Recommendations

- community approach to construction and maintenance of protection works is recommended
- vertical seawalls and retaining walls are not recommended
- intercept surface runoff and convey down bluff to beach in closed drainage system
- any new groyne construction should include prefilling of groyne cells with suitable beach sand (clean sand and gravel, $D_{50} >$ 0.3mm)
- where additional protection is required during periods of high lake levels, sloping rubblemound revetment along toe of bluff is recommended approach
- for more detailed information and guidance, refer to the supporting document entitled Design Considerations for Shore Protection Structures (Baird, 1992), and, MNR (1986) and USA COE (1977, 1981)

Management Area Delineation

- Shoreline Area 1 - between the water's edge and a line defined by the slope stability allowance measured landward from the toe of the bluff
- Shoreline Area 2 - between Shoreline Area 1 and a line defined by a 30 metre erosion allowance measured from the top of the bluff (Erosion Hazard Limit)

Blue Point Bay

Legend

- Shoreline Area 1
- Shoreline Area 2

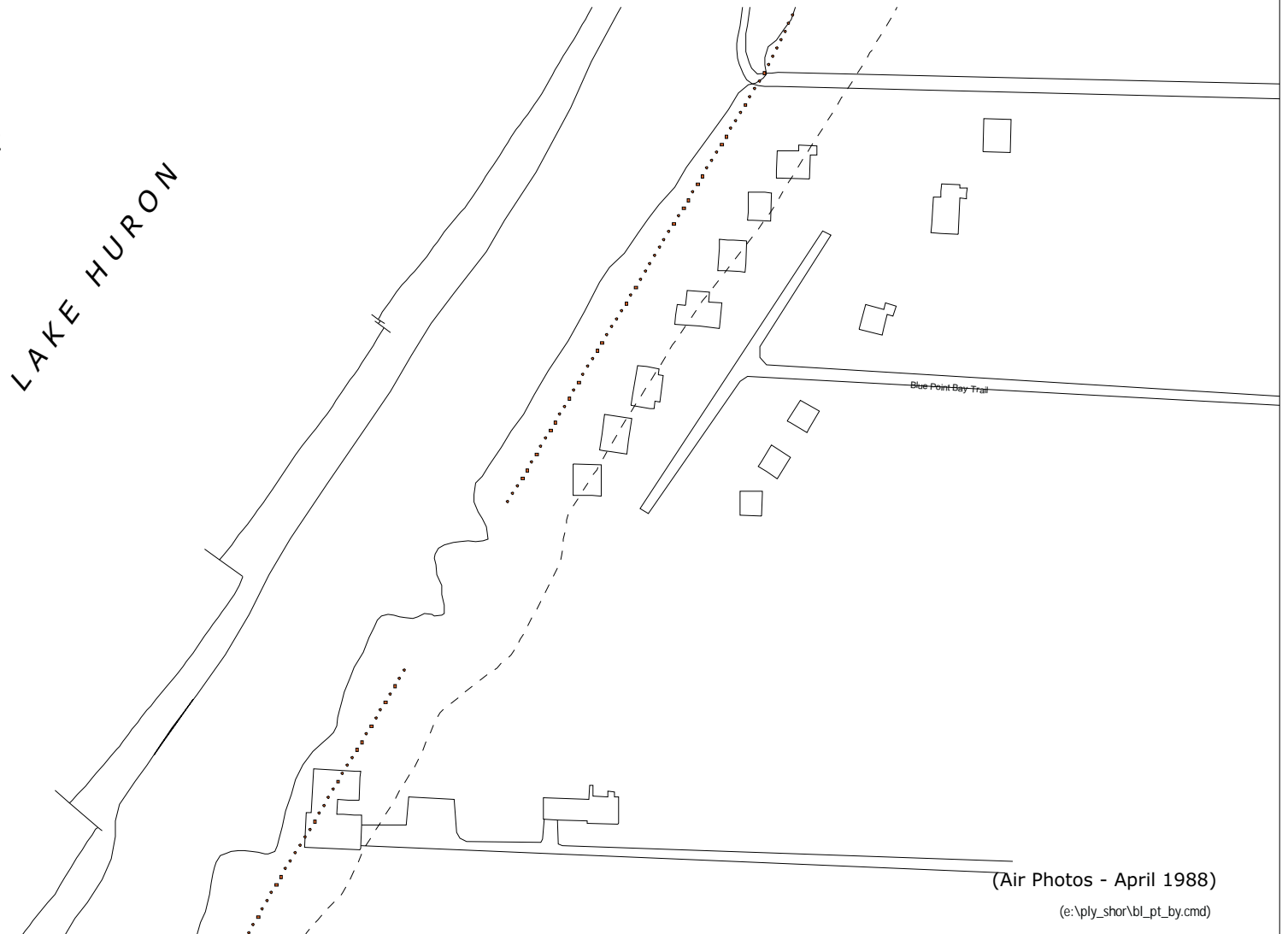
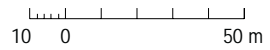


Figure 30

HURON STREET
(Registered Plan 25)
Plympton Township

Map Sheet # 18 (Measurement Numbers 684-688)

Shoreline Characteristics

- beach - sand, gravel and cobble beach typically \pm 5 metres wide at normal summer water levels, becoming narrow during periods of high lake levels
- bluff - high bluff; well vegetated with mature trees
 - some localized instability (creep, slumping) due to previous toe erosion by wave action, and landside influences (drainage, groundwater seepage, etc.)
 - gully development prevalent
- development - seasonal and permanent residential development
 - dwellings located along the top of bluff
- protection works - gabion basket groynes; supplemented at two locations with gabion basket seawalls

Erosion Issues

- long term recession rate is generally low at $<$ 0.3 metres/year
- beach erosion and toe of bluff erosion caused by wave uprush during storms and high lake level periods

Objective of Protection Works

- limit storm wave uprush damages and toe of bluff erosion

Recommendations

- community approach to construction and maintenance of protection works is recommended
- vertical seawalls and retaining walls are not recommended
- intercept surface runoff and convey down bluff to beach in closed drainage system
- where additional protection is required during periods of high lake levels, sloping rubblemound revetment along toe of bluff is recommended approach
- for more detailed information and guidance, refer to the supporting document entitled Design Considerations for Shore Protection Structures (Baird, 1992), and, MNR (1986) and USA COE (1977, 1981)

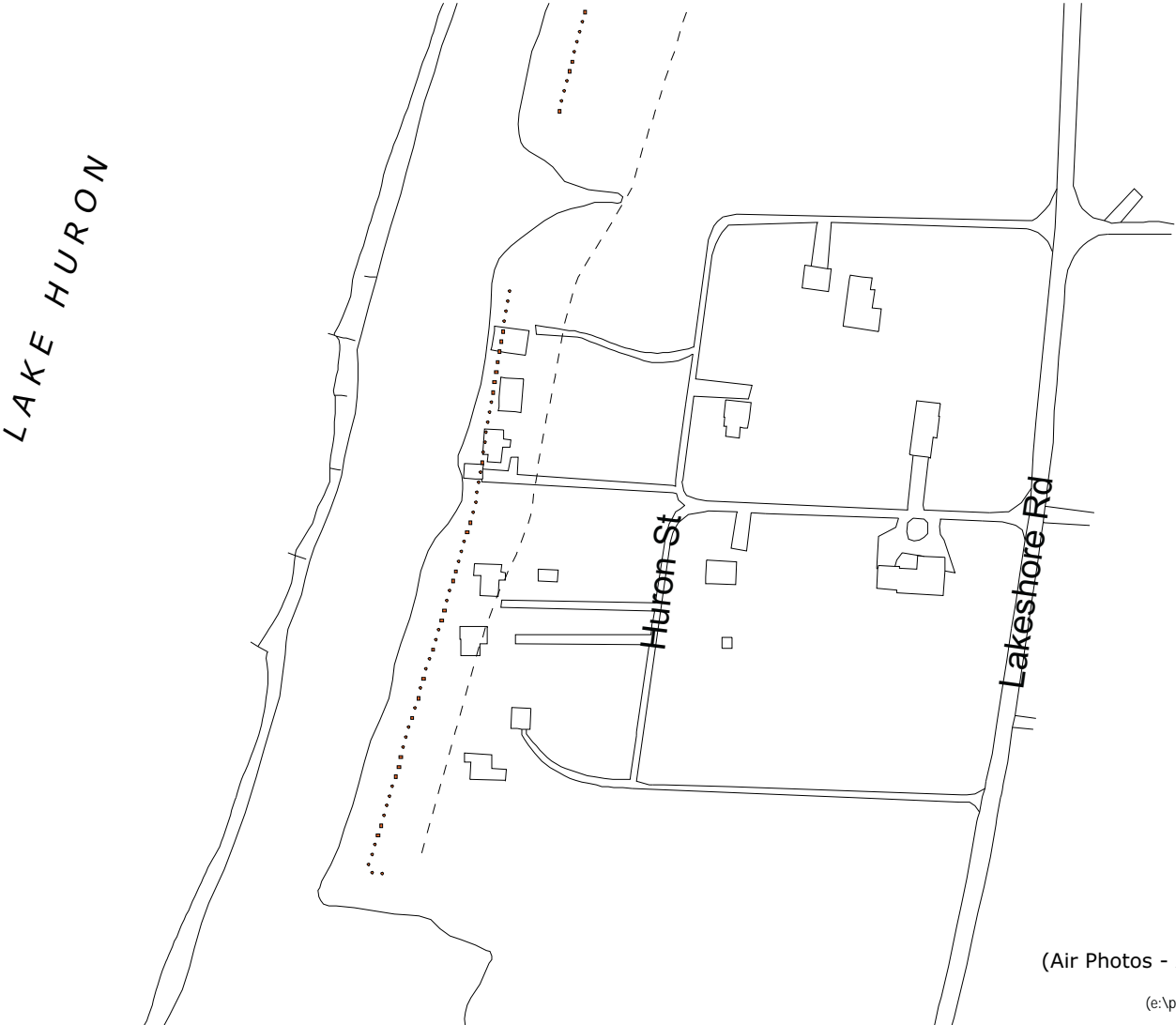
Management Area Delineation

- Shoreline Area 1 - between the water's edge and a line defined by the slope stability allowance measured landward from the toe of the bluff
- Shoreline Area 2 - between Shoreline Area 1 and a line defined by a 30 metre erosion allowance measured from the top of the bluff (Erosion Hazard Limit)

Huron Street

Legend

- Shoreline Area 1
- Shoreline Area 2



(Air Photos - April 1988)

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Figure 31

BLUE POINT SUBDIVISION

(Registered Plan 28)

Plympton Township

Map Sheets #19 and #20 (Measurement Numbers 582-608)

Shoreline Characteristics

- beach - sand beach typically \pm 5 metres wide at normal summer water levels, becoming narrow or non-existent during periods of high lake levels
- bluff - high bluff; steep and eroding; sparsely vegetated with seasonal grasses/small shrubs
- development
 - permanent residential development with several vacant lots of record
 - dwellings located at top of bluff
- protection works
 - majority of shoreline bluff unprotected
 - several steel sheet pile groynes; some groynes supplemented with vertical sheet pile seawalls

Erosion Issues

- long term recession rate is generally high at $>$ 0.6 metres/year
- undercutting at the toe of the bluff by wave action causes instability and success shallow slips on the bluff face but also deeper internal rotational slumps
- wave uprush during storm events is intensified during periods of high lake levels
- instability aggravated by landside influences (drainage, loading, groundwater seepage, etc.)

Objective of Protection Works

- stabilize shoreline from future recession by preventing erosion by wave action at toe of bluff

Recommendations

- community approach to construction and maintenance of protection works is recommended
- vertical seawalls and retaining walls are not recommended
- **CONSIDER RELOCATION AND MOVEABLE DWELLING DESIGNS** instead of protection works
- engineered sloping rubblemound revetment constructed along toe of bluff is recommended approach to protect shoreline from continual erosion; bluff stabilization measures (grading, drainage, vegetation) necessary in conjunction with protection works; **revetment design must consider beach stability and erosion (downcutting) of the nearshore lake bottom**
- maintain existing groynes; where groyne cells are not full "nourish" with suitable beach sand (clean sand and gravel, $D_{50} > 0.3\text{mm}$)
- intercept surface runoff and convey landward to storm drainage system or over bluff face and down to beach in closed drainage system
- for more detailed information and guidance, refer to the supporting document entitled Design Considerations for Shore Protection Structures (Baird, 1992), and, MNR (1986) and USA COE (1977, 1981)

Management Area Delineation

- Shoreline Area 1 - between the water's edge and a line defined by the slope stability allowance measured landward from the toe of the bluff
- Shoreline Area 2 - between Shoreline Area 1 and a line defined by the slope stability allowance plus 100 times the average annual recession rate (Erosion Hazard Limit)

Blue Point Subdivision

Legend

- Shoreline Area 1
- Shoreline Area 2

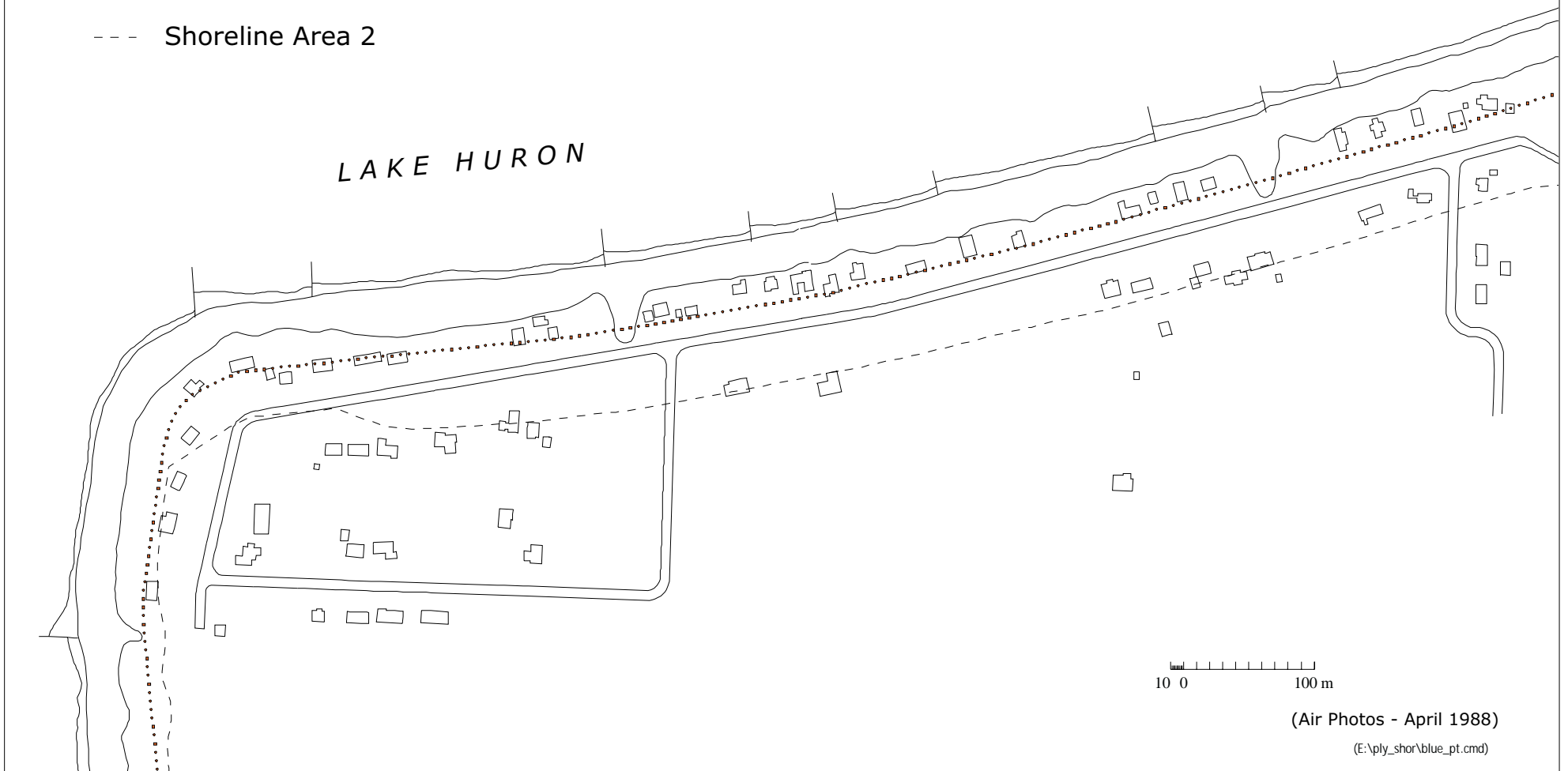


Figure 32

SUNSET ACRES
(Registered Plan 448)
Plympton Township

Map Sheet #20 (Measurement Numbers 610-627)

Shoreline Characteristics

- beach - sand beach typically \pm 5 metres wide at normal summer water levels, becoming narrow or non-existent during periods of high lake levels
- bluff - high bluff; steep and eroding; sparsely vegetated with seasonal grasses/small shrubs
- development - permanent residential development with numerous vacant lots of record
- dwellings located along the top of bluff
- protection works - majority of shoreline bluff unprotected
- two steel sheet pile groynes

Erosion Issues

- long term recession rate is generally high at $>$ 0.6 metres/year
- undercutting at the toe of the bluff by wave action causes instability and success shallow slips on the bluff face but also deeper internal rotational slumps
- wave uprush during storm events is intensified during periods of high lake levels
- instability aggravated by landside influences (drainage, loading, groundwater seepage, etc.)

Objective of Protection Works

- stabilize shoreline from future recession by preventing erosion by wave action at the toe of bluff

Recommendations

- community approach to construction and maintenance of protection works is recommended
- vertical seawalls and retaining walls are not recommended
- engineered sloping rubblemound revetment constructed along toe of bluff is recommended approach to protect shoreline from continual erosion; bluff stabilization measures (grading, drainage, vegetation) necessary in conjunction with protection works
- revetment design must consider beach stability and erosion (downcutting) of the nearshore lake bottom
- maintain existing groynes; where groyne cells are not full "nourish" with suitable beach sand (clean sand and gravel, $D_{50} >$ 0.3mm)
- intercept surface runoff and convey landward to storm drainage system or over bluff face and down to beach in closed drainage system
- for more detailed information and guidance, refer to the supporting document entitled Design Considerations for Shore Protection Structures (Baird, 1992), and, MNR (1986) and USA COE (1977, 1981)

Management Area Delineation

- Shoreline Area 1 - between the water's edge and a line defined by the slope stability allowance measured landward from the toe of the bluff
- Shoreline Area 2 - between Shoreline Area 1 and a line defined by the slope stability allowance plus 100 times the average annual recession rate (Erosion Hazard Limit)

Sunset Acres

Legend

- Shoreline Area 1
- Shoreline Area 2

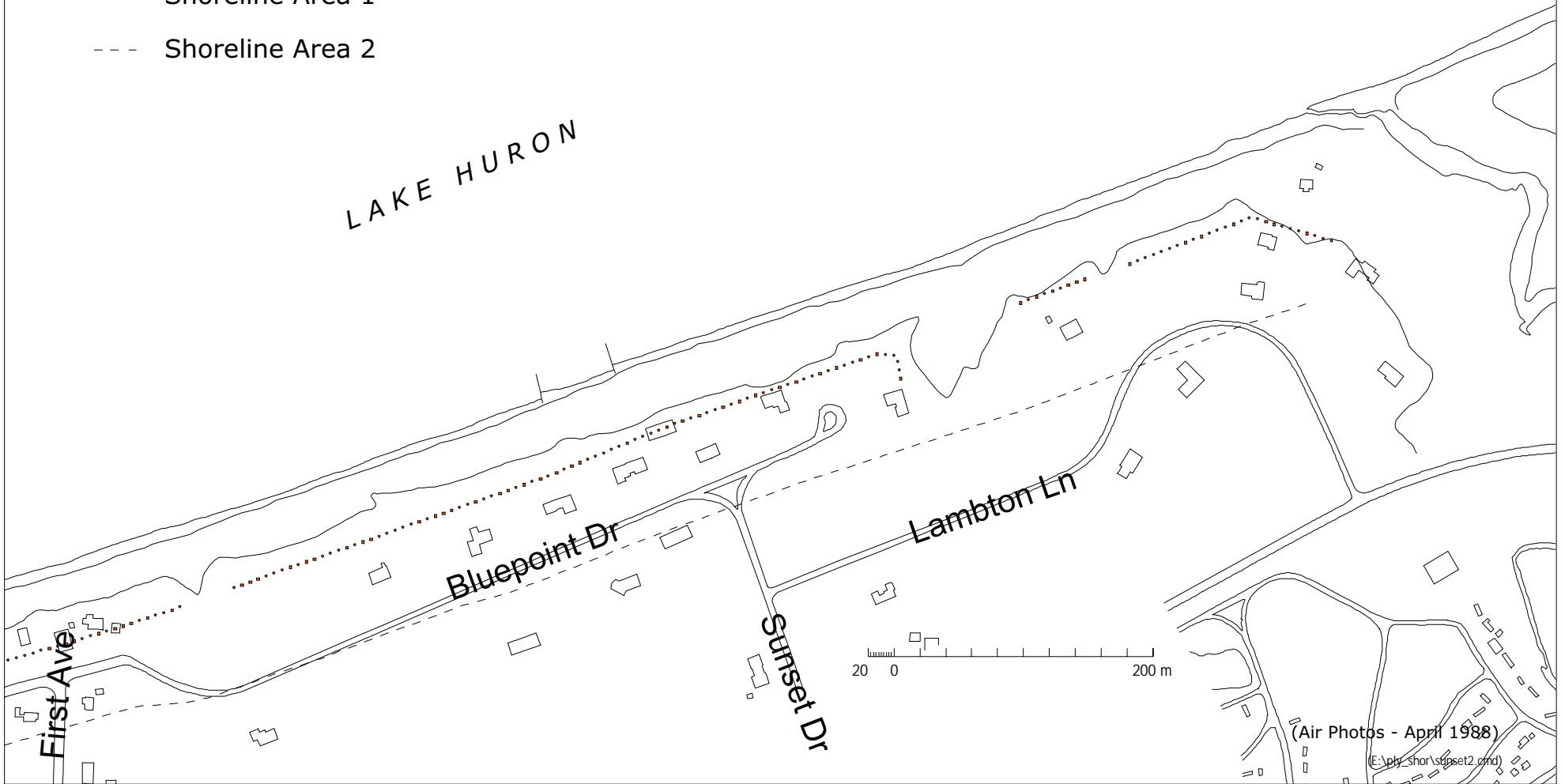


Figure 33

GALLIMERE BEACH

(Registered Plans 17 and 23)
Plympton Township

Map Sheet #21 (Measurement Numbers 684-688)

Shoreline Characteristics

- beach - sand beach typically \pm 10 metres wide at normal summer water levels, becoming narrow during periods of high lake levels
- bluff - high bluff; well vegetated with mature trees
 - several areas of localized instability (creep, slumping) due to previous toe erosion by wave action, and landside influences (drainage, loading, groundwater seepage, etc.)
- development
 - seasonal residential development; some conversion to permanent residences
 - cottages located along the top of bluff
- protection works - steel sheet pile groynes

Erosion Issues

- long term recession rate is generally low at < 0.3 metres/year
- beach erosion and toe of bluff erosion caused by wave uprush during storms and high lake level periods

Objective of Protection Works

- limit storm wave uprush damages and toe of bluff erosion
- provide recreational beach

Recommendations

- community approach to construction and maintenance of protection works is recommended
- vertical seawalls and retaining walls are not recommended
- maintain existing groynes
- intercept surface runoff and convey down bluff to beach in closed drainage system
- if additional protection from wave uprush is required during periods of high lake levels, "nourish" existing groyne cells with suitable beach sand (clean sand and gravel, $D_{50} > 0.3\text{mm}$)
- where additional protection of toe of bluff is required and/or beach nourishment not feasible, construct sloping rubblemound revetment along toe of bluff to reduce wave impact and beach erosion
- for more detailed information and guidance, refer to the supporting document entitled Design Considerations for Shore Protection Structures (Baird, 1992), and, MNR (1986) and USA COE (1977, 1981)

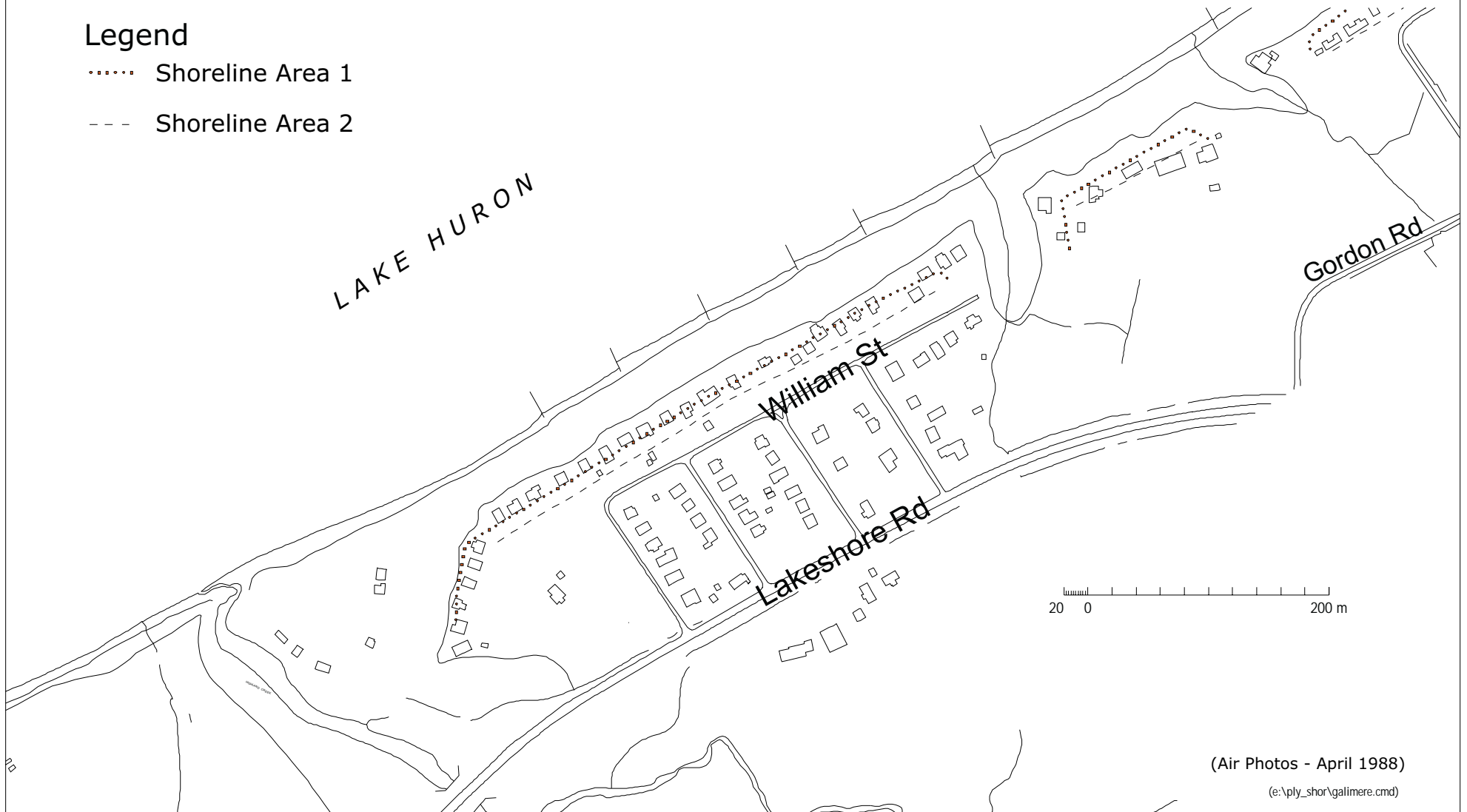
Management Area Delineation

- Shoreline Area 1 - between the water's edge and a line defined by the slope stability allowance measured landward from the toe of the bluff
- Shoreline Area 2 - between Shoreline Area 1 and a line defined by a 30 metre erosion allowance measured from the top of the bluff (Erosion Hazard Limit)

Gallimere Beach

Legend

- Shoreline Area 1
- Shoreline Area 2



(Air Photos - April 1988)

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Figure 34

HILLCREST HEIGHTS

(Registered Plans 31, 34 and 440)
Plympton Township

Map Sheets #21 and #22 (Measurement Numbers 684-688)

Shoreline Characteristics

- beach - sand beach typically \pm 10 metres wide at normal summer water levels, becoming narrow during periods of high lake levels
- bluff - high bluff; well vegetated with mature trees
 - several areas of localized instability (creep, slumping) due to previous toe erosion by wave action, and landside influences (drainage, groundwater seepage, etc.)
- development - permanent residential development interspersed with some cottage residences
 - dwellings located along the top of bluff
- protection works - varies from no protection to irregularly spaced steel sheet pile groynes and, gabion basket and concrete seawalls

Erosion Issues

- long term recession rate is generally low at < 0.3 metres/year
- beach erosion and toe of bluff erosion caused by wave uprush during storms and high lake level periods

Objective of Protection Works

- limit storm wave uprush damages and toe of bluff erosion
- provide recreational beach

Recommendations

- community approach to construction and maintenance of protection works is recommended
- vertical seawalls and retaining walls are not recommended
- maintain existing groynes
- intercept surface runoff and convey down bluff to beach in closed drainage system
- if additional protection from wave uprush is required during periods of high lake levels, "nourish" existing groyne cells with suitable beach sand (clean sand and gravel, $D_{50} > 0.3\text{mm}$)
- where additional protection of toe of bluff is required and/or beach nourishment not feasible, construct sloping rubblemound revetment along toe of bluff to reduce wave impact and beach erosion
- any new groyne construction should include prefilling of groyne cells with suitable beach sand
- for more detailed information and guidance, refer to the supporting document entitled Design Considerations for Shore Protection Structures (Baird, 1992), and, MNR (1986) and USA COE (1977, 1981)

Management Area Delineation

- Shoreline Area 1 - between the water's edge and a line defined by the slope stability allowance measured landward from the toe of the bluff
- Shoreline Area 2 - between Shoreline Area 1 and a line defined by a 30 metre erosion allowance measured from the top of the bluff (Erosion Hazard Limit)

Hillcrest Heights

Legend

- Shoreline Area 1
- Shoreline Area 2

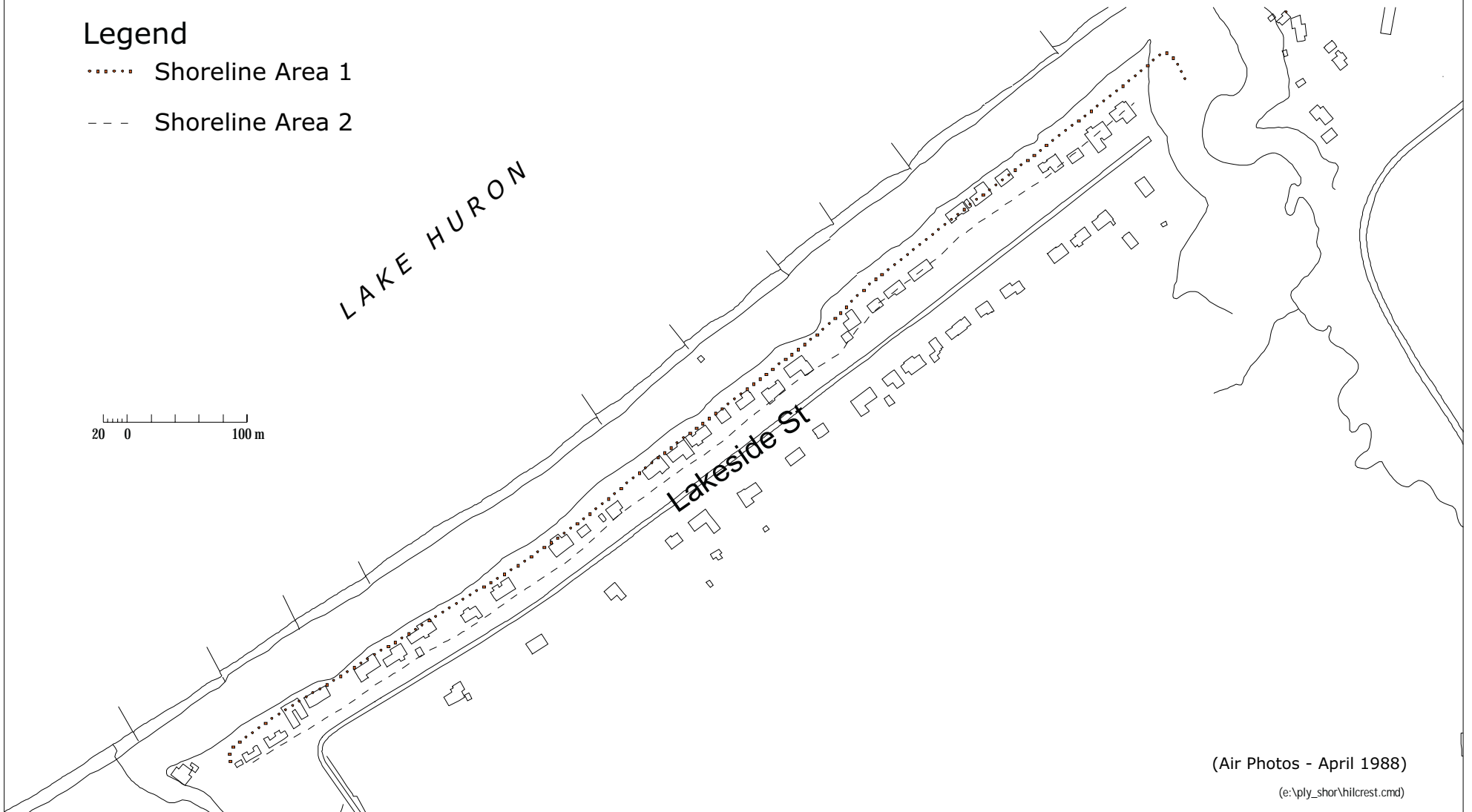


Figure 35

INVERCAIRN BEACH

(Registered Plan 27)

Plympton Township

Map Sheet #22 (Measurement Numbers 684-688)

Shoreline Characteristics

- beach - sand beach typically \pm 15 metres wide at normal summer water levels, becoming narrower during periods of high lake levels
- bluff - high bluff; well vegetated with mature trees
 - some localized instability (creep, slumping) due to previous toe erosion by wave action, and landside influences (drainage, groundwater seepage, etc.)
- development
 - seasonal residential development; some conversion to permanent residences
 - cottages located along the top of bluff
- protection works - steel sheet pile groynes; constructed by subdivision community during mid-1970's

Erosion Issues

- long term recession rate is generally low at < 0.3 metres/year
- beach erosion and minor toe of bluff erosion caused by wave uprush during storms and high lake level periods

Objective of Protection Works

- limit storm wave uprush damages
- provide recreational beach

Recommendations

- community approach to construction and maintenance of protection works is recommended
- vertical seawalls and retaining walls are not recommended
- maintain existing groynes
- intercept surface runoff and convey down bluff to beach in closed drainage system
- if additional protection from wave uprush is required during periods of high lake levels, "nourish" existing groyne cells with suitable beach sand (clean sand and gravel, $D_{50} > 0.3\text{mm}$)
- where additional protection of toe of bluff is required and/or beach nourishment not feasible, construct sloping rubblemound revetment along toe of bluff to reduce wave impact and beach erosion
- for more detailed information and guidance, refer to the supporting document entitled Design Considerations for Shore Protection Structures (Baird, 1992)), and, MNR (1986) and USA COE (1977, 1981)

Management Area Delineation

- Shoreline Area 1 - between the water's edge and a line defined by the slope stability allowance measured landward from the toe of the bluff
- Shoreline Area 2 - between Shoreline Area 1 and a line defined by a 30 metre erosion allowance measured from the top of the bluff (Erosion Hazard Limit)

Invercairn Beach

Legend

- Shoreline Area 1
- Shoreline Area 2



Figure 36

MOORINGS SUBDIVISION and FISHER BEACH

Plympton Township

Map Sheet #22 (Measurement Numbers 688-693)

Shoreline Characteristics

- beach - sand beach typically \pm 10 metres wide at normal summer water levels, becoming narrow during periods of high lake levels
- bluff - high bluff; well vegetated with mature trees
 - some localized instability (creep, slumping) due to previous toe erosion by wave action, and landside influences (drainage, etc.)
- development
 - seasonal residential development
 - cottages located on bluff face in Fisher Beach
 - cottages in Moorings located along the top of bluff
- protection works - varies from steel sheet pile groynes, to groynes supplemented by vertical sheet pile seawalls

Erosion Issues

- long term recession rate is generally low at < 0.3 metres/year
- beach erosion and wave uprush damage during storms and high lake level periods

Objective of Protection Works

- limit storm wave uprush damages
- provide recreational beach

Recommendations

- community approach to construction and maintenance of protection works is recommended
- vertical seawalls and retaining walls are not recommended
- maintain existing groynes
- intercept surface runoff and convey down bluff to beach in closed drainage system
- is additional protection from wave uprush is required during periods of high lake levels, "nourish" existing groyne cells with suitable beach sand (clean sand and gravel, $D_{50} > 0.3\text{mm}$)
- where additional protection of toe of bluff is required and/or beach nourishment not feasible, supplement or replace existing vertical walls with sloping rubblemound revetments to reduce wave impact and beach erosion
- for more detailed information and guidance, refer to the supporting document entitled Design Considerations for Shore Protection Structures (Baird, 1992), and, MNR (1986) and USA COE (1977, 1981)

Management Area Delineation

- Shoreline Area 1 - between the water's edge and a line defined by the slope stability allowance measured landward from the toe of the bluff
- Shoreline Area 2 - between Shoreline Area 1 and a line defined by a 30 metre erosion allowance measured from the top of the bluff (Erosion Hazard Limit)

Moorings Subdivision and Fisher Beach

Legend

- Shoreline Area 1
- Shoreline Area 2

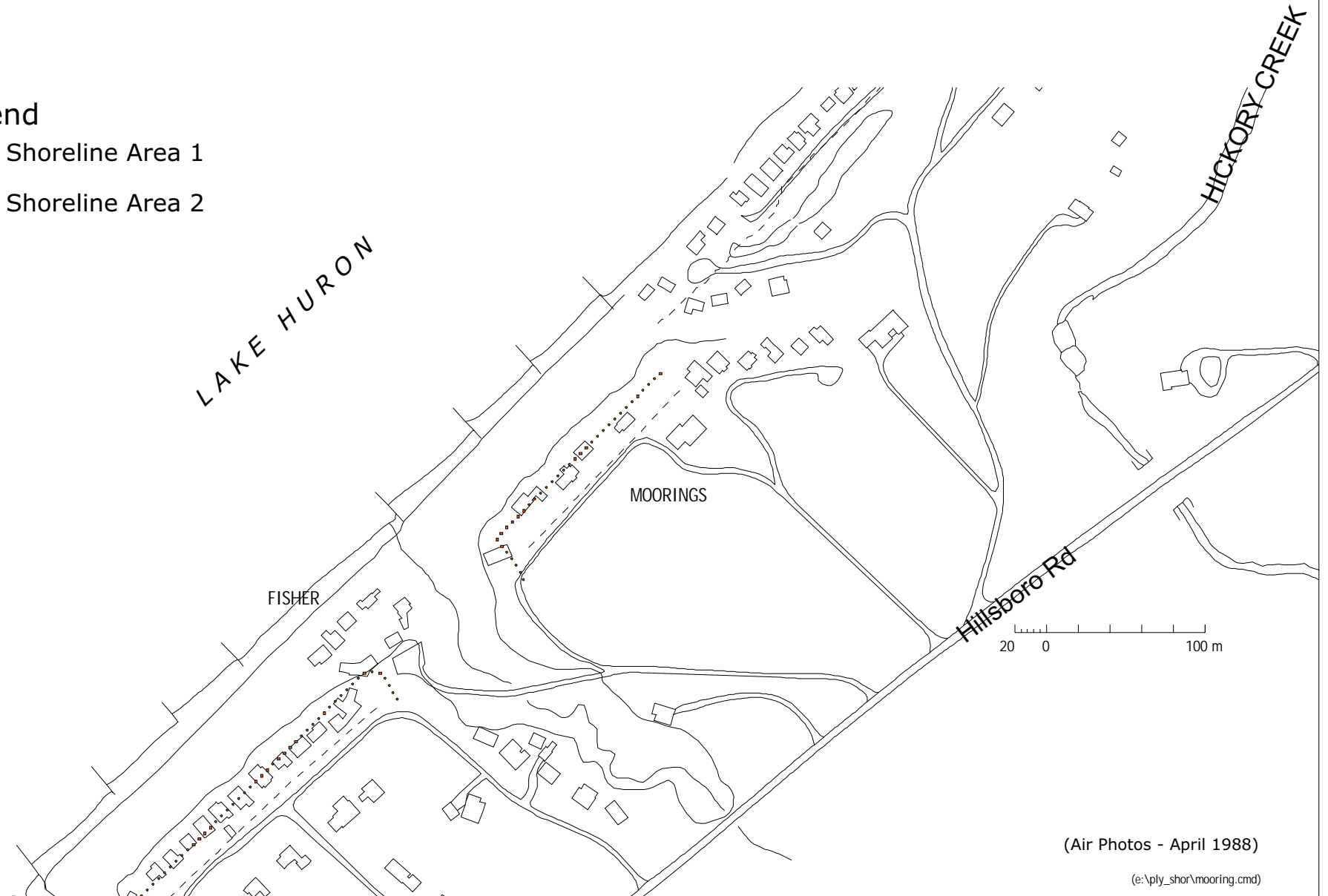


Figure 37

HILLSBORO BEACH (North and South)

(includes Registered Plan 26)

Plympton Township

Map Sheet #22 (Measurement Numbers 694-706)

Shoreline Characteristics

- beach - sand beach typically \pm 10 metres wide at normal summer water levels, becoming narrow during periods of high lake levels
 - Hillsboro South on remnant dune feature located between beach and backshore bluff
- bluff - high bluff in Hillsboro North; well vegetated with mature trees
 - some localized instability due to landside influences (drainage, loading, etc.)
- development
 - seasonal residential development
 - cottages located on bluff face and along top of bluff in Hillsboro North
 - cottages in Hillsboro South located on remnant dune feature at the beach
- protection works - steel sheet pile groynes supplemented by vertical sheet pile, concrete and rock seawalls and retaining walls, and rubble mounds

Erosion Issues

- long term recession rate is generally low at < 0.3 metres/year
- beach erosion and wave uprush damage during storms and high lake level periods
- historical damage to protection works, property and structures located on the bluff face/beach

Objective of Protection Works

- limit storm wave uprush damages
- provide recreational beach

Recommendations

- community approach to construction and maintenance of protection works is recommended
- maintain existing groynes; where groyne cells are not full, "nourish" with suitable beach sand (clean sand and gravel, $D_{50} > 0.3\text{mm}$)
- vertical seawalls and retaining walls are not recommended
- supplement or replace existing vertical walls with sloping rubblemound revetments to reduce wave impact and beach erosion
- any new groyne construction should include prefilling of groyne cells with suitable beach sand
- for more detailed information and guidance, refer to the supporting document entitled Design Considerations for Shore Protection Structures (Baird, 1992), and, MNR (1986) and USA COE (1977, 1981)

Management Area Delineation

- Shoreline Area 1 - between the water's edge and a line defined by the slope stability allowance measured landward from the toe of the bluff (Hillsboro North) or a line defined by the 100 year flood line plus a 15 metre wave uprush allowance (Hillsboro South)
- Shoreline Area 2 - between Shoreline Area 1 and a line defined by a 30 metre erosion allowance measured from the top of the bluff (Hillsboro North) or a line defined by the 100 year flood line plus a 30 metre erosion allowance (Hillsboro South)

Hillsboro Beach

Legend

- Shoreline Area 1
- Shoreline Area 2

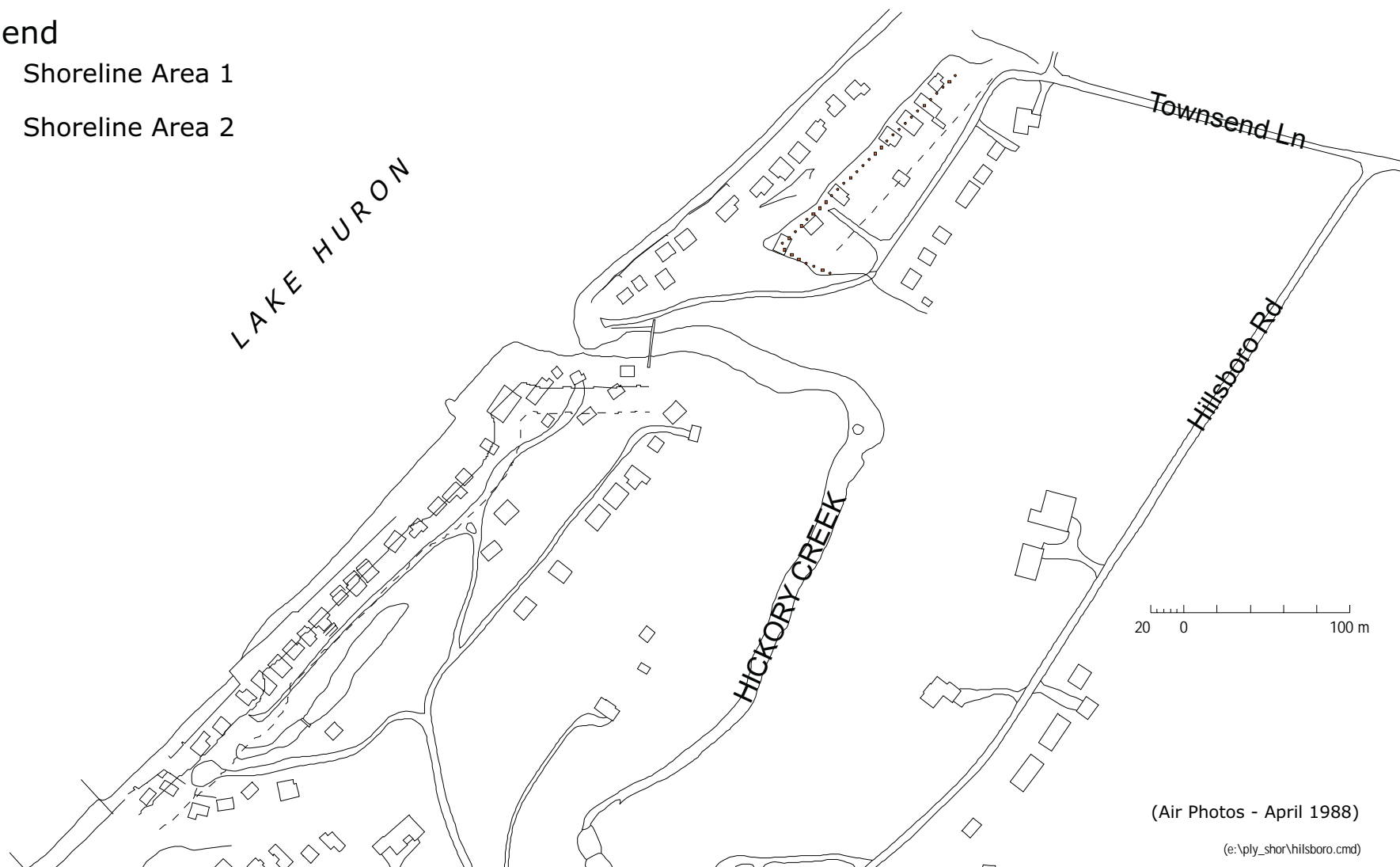


Figure 38

(e:\ply_shor\hillsboro.cmd)

Section 5 Implementation

5.0 Monitoring of Hazards

Recession (Erosion) Rates

Comprehensive monitoring of erosion along the study area shoreline began in the early 1970's by Environment Canada and the Ontario Ministry of Natural Resources. Long term recession and accretion rates were established by comparing aerial photographs from 1952 and 1973 to determine changes in the location of shoreline features such as the top of the bluff and the water's edge. Additional information was developed through ground survey methods by surveying cross sections at selected intervals along the shoreline to establish the locations of bluff features. These survey methods were used to record shoreline changes at regular intervals between 1971 and 1973. The results of the monitoring were published in 1975 as part of the Canada/Ontario Great Lakes Shore Damage Survey (Environment Canada and OMNR).

The ground survey component of the Canada/Ontario Great Lakes Shore Damage Survey was continued under the Canada/Ontario Great Lakes Erosion Monitoring Programme (Boyd, 1981) by Fisheries and Oceans Canada between 1973 and 1980. Under this program shoreline cross sections were surveyed annually and following significant erosion events. The study area shoreline contained 10 of the survey sites as shown on Figure 39.

The monitoring program was abandoned for several years until 1988 when responsibility for shoreline management and planning within the study area was conferred to the St. Clair Region Conservation Authority. Since that time, the Conservation Authority has undertaken to monitor the remaining survey sites and resurvey the shoreline profile following erosion events. The continued collection of information using ground survey methods will provide the necessary data to update existing recession rate information provided through the supporting document entitled Lake Huron Erosion Hazard Delineation Study (1991) and to verify information collected by other methods including air photo interpretation. This will ensure that the information used in the SMP to evaluate management alternatives and implement appropriate development controls will continue to provide an accurate representation of the extent of the erosion hazard.

Nearshore Lake Bottom Erosion

The erosion or downcutting of the nearshore lake bottom is a principal factor influencing the recession of the adjacent bluff above the waterline. In many areas there is a direct correlation between the downcutting of the nearshore lake bottom and the recession of the adjacent bluff. Bluff areas experiencing significant recession over the long term can be expected to have a nearshore lake bottom composed of materials easily eroded by wave action. Protection works constructed to prevent bluff recession in these areas are often not designed to address the corresponding nearshore lake bottom erosion. As a result, water depths adjacent these structures continue to increase over time which can lead to instability and failure.

Future residential development along the shoreline should be planned for based on long term recession rate data. In addition, many existing developments rely on protection works to prevent erosion damages to buildings and structures. The monitoring of nearshore lake bottom erosion will assist in predicting future rates of bluff recession and what affect the downcutting process will have on the future stability of existing protection works.

Accurate and reliable bathymetric surveys of the nearshore lake bottom generally do not exist within the study area although limited profiles are available at some locations. Information on the composition of the nearshore lake bottom is also limited. The data available was compiled by cores,

jet probes and samples on the lake bottom in water depths of 2 to 20 metres with the majority of samples in depths greater than 10 metres. As a result, the data is of limited use in defining the composition of the very nearshore lake bottom (depths less than 2 metres), which is the section of the profile that influences bluff erosion.

A monitoring program should be established to collect information specific to the study area shoreline including detailed surveys of bathymetry and lake bottom composition. Monitoring sites should be selected to represent developed areas experiencing bluff recession and developed areas relying on protection works. These sites should be located within or adjacent to public lands in order to ensure continued access to the sites over the long term.

Erosion Events

The offices of Plympton Township, the City of Sarnia and the Conservation Authority are not located adjacent the shoreline. As a result, municipal and Conservation Authority staff have not been able to monitor shoreline conditions on a continuous basis. To facilitate this regular monitoring and to improve communications with the shoreline community, a volunteer network of knowledgeable and interested shoreline residents could be established. These residents could monitor conditions at the shoreline and contact the office of the local municipality and the Conservation Authority following significant erosion events such as bluff slumping or storm damage to property and protection works.

The monitoring network should include residents located in high bluff areas experiencing historical erosion rates greater than 0.3 metres per year, and low bluff and beach areas which have experienced historical storm damage to protection works and property. The high bluff areas should include the Blue Point subdivision in Plympton Township where high groundwater levels during the spring months contribute to slumping events. The low bluff areas should include areas such as Hillsboro Beach in Plympton Township and the Braemar Lane - Haight Lane area of Sarnia.

5.1 Emergency Response

Riverine Flooding

It is the responsibility of the Conservation Authority to provide a regional flood advisory system and to coordinate the response to a flood emergency. The Conservation Authority maintains an Emergency Flood Contingency Plan. The current emergency plan focuses on the existing riverine development which was built without the benefit of present-day standards for flood hazard mitigation. The plan combines local watershed information with data obtained from the Streamflow Forecast Centre of the Ministry of Natural Resources. Copies of the plan are kept in every municipal office affected by riverine flooding and an up-to-date list of municipal contacts is maintained. The Conservation Authority also assists the municipalities in the preparation of their local flood emergency response plans.

Municipalities have the first responsibility for the safety of their citizens in a flood emergency. Each municipality should have an emergency plan. A municipality which has put an emergency plan into action may request that the Minister of Natural Resources declare a Provincial Emergency in the event that the resources of the municipality are inadequate to deal with the flood situation.

Shoreline Flooding and Erosion Events

In riverine flood events, damages are usually associated with water damage to furnishings and foundation damages due to hydrostatic uplift. Damages experienced within the flooding hazard area along the shoreline are usually associated with wave uprush and wave impact damages to

protection works, property and buildings in the low bluff and beach areas. While there are no homes located below the 100 year flood level, there are several dwellings located within the area affected by the wave uprush allowance represented by Shoreline Area 1. Section 3.4.1 describes the criteria used to identify this management area. Damage or failure of protection works in these areas can leave adjacent dwellings at risk.

The risk of storm damages and erosion in the low bluff and beach areas is high during high lake level conditions. As such, short term maintenance operations on protection works should be undertaken when lake levels are rising and before severe storms occur. The Great Lakes Water Levels Bulletin is published monthly by the Canadian Hydrographic Service of the Department of Fisheries and Oceans at Environment Canada. The Bulletin includes graphs of water levels recorded at a network of gauging stations and provides a six month forecast of the probable range of future water levels. The bulletin is distributed free of charge as a public service and is also available over the World Wide Web at <http://csx.cciw.ca/dfo/chs/danpd/tcw/tcwI-home.html>.

During the most recent high water level period between 1985 and 1987, the Great Lakes Water Level Communications Centre of Environment Canada notified news services and the Streamflow Forecast Centre of predicted storm surge events. These surge events were predicted using lake wide circulation models which utilized information on forecasted winds. When lake levels dropped and the severe risk of flooding diminished, the formal warning system was discontinued.

In the high bluff areas there are numerous existing residential dwellings located within Shoreline Area 1 and in close proximity to the top of the shoreline bluff. Where the bluff adjacent these dwellings is experiencing continued recession, the risk of damage due to bluff slumping continues to increase. The municipalities with the assistance of the Conservation Authority, should develop criteria and investigate appropriate procedures for informing landowners with dwellings that are at serious risk of damage due to bluff instability. Such criteria should include dwellings located within Shoreline Area 1 in the high bluff areas. Criteria should focus attention on areas experiencing continued moderate to severe bluff recession with evidence of recent bluff slumping and tension crack formations.

The equipment used to lift and move buildings can be heavy and bulky. As such, the dwelling should be moved while there is still adequate space around the dwelling for safe access. Where the moving operation does not commence until after the structure is damaged, the safety of equipment and workers can be at risk and moving costs can be higher. A list of qualified and reputable house movers should be maintained to assist landowners with their decision making process.

Section 6 Public Involvement

6.0 Shoreline Management Advisory Committee

The process to finalize the SMP began in 1991 following the completion of background studies between 1987 and 1990. These studies provided a knowledge base to support decisions on management alternatives for the future use of the shoreline. During the data collection stage, it was recognized that there were many stakeholders involved in various uses of the shoreline and that the SMP would benefit from the participation of these groups and individuals. The advisory committee was formed to obtain feedback on management alternatives and provide a forum for public input at an early stage in the process. Cottage communities and individual shoreline landowners were represented on the Committee. These individuals had direct knowledge of their shoreline areas and provided a connection to the shoreline community. The municipalities were represented on the Committee by staff of the Township, City and County. These members would eventually assist in the implementation of shoreline policies and programs. Staff of the Ministry of Natural Resources were included due to their knowledge of province wide planning policies and Crown land management legislation. Members of the Conservation Authority Board of Directors were included to represent the interests and responsibilities of the Conservation Authority as well as their respective municipalities. The Committee benefited from the initial participation of a coastal engineering consultant who was able to provide direction on technical issues related to protection works and natural shoreline processes. Finally, staff of the Conservation Authority were included to facilitate meetings, provide support and maintain continuity in the process. The Committee held nine (9) meetings between August of 1991 and November of 1995. The minutes of these meetings and written comments received from Committee members are found in Appendix B.

The Committee experienced numerous membership changes due to the length of the SMP completion process. The completion process became lengthy due to its connection with the parallel process being undertaken by the Ministry of Natural Resources to finalize land use planning policies for the shorelines of the Great Lakes. This resulted in an irregular meeting schedule with long periods of inactivity while the Provincial Shoreline Policy underwent changes. During this period, many of the groups represented on the Committee experienced changes in staff and membership which affected the makeup of the SMP Committee. These changes resulted in a continual process of informing new members of SMP issues.

Committee Membership

Conservation Authority Directors

Sarnia	Mary Jo Anning	1991
	Patrick O'Brien	1992
	David Boushy	1993
	Patrick O'Brien	1995-96
Plympton	Elizabeth Tenhoeve	1991-96
Forest	Roger Sutherland	1995-96
Provincial Appointee	William Boyd	1995
<u>Ministry of Natural Resources</u>	Ezio Nadalin	1991-92

Municipal Staff

Plympton	Netty McEwen	1991-96
Sarnia	Peter Hungerford	1991-96
Lambton County	Steve Evans Monica Bacic	1991-93 1995-96

Plympton Shoreline Community

Gallimere Beach Association	William White Bob Tordoff Don Wilson	1991 1992-93 1995-96
Hillsboro Beach Association	John Manning	1991-96
Shoreline Resident	Bill Robertson	1991-96

Sarnia Shoreline Community

Shoreline Resident	Maurice Lamoureux	1991-93
Shoreline Resident	John Rozema	1991-93
Shoreline Resident	Laird Nixon	1991-96
Shoreline Resident	Norman Carr	1995-96

Coastal Engineer

Bill Baird	1991-92
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Conservation Authority Staff

Patricia Hayman	1991-96
David Sawyer	1991-96

Terms of Reference

1. To make recommendations on SMP content, structure and implementation, to meet the shoreline management objectives of the Conservation Authority and the policies of the Province of Ontario.
2. To review and provide feedback on policy alternatives, and comment on technical issues related to shoreline management approaches.
3. To finalize the SMP, endeavouring to reach agreement by general consensus.

The first task of the Committee was to compile a list of issues which committee members felt should be addressed in the SMP. Additional issues were added which would need to be addressed to meet the objectives of the Province of Ontario and the MNR Guidelines for Developing Great Lakes Shoreline Management Plans. The principal issue of importance to members representing the shoreline community was that the SMP should provide information and direction to property owners on the appropriate means of protecting their properties from erosion. It was important to the Conservation Authority that the SMP contain a management approach to address existing and future development adjacent the shoreline within the context of the Provincial Shoreline Policy Statement.

Provincial Shoreline Policy

The development of the Provincial Shoreline Policy is outlined under Section 3.1. During the SMP process, it was necessary for the Committee to work with a draft policy document which had not yet received the required Provincial government approval or undergone the necessary public review process. This created difficulties for the Committee and Conservation Authority staff because of the uncertainty of the Provincial approach. It became difficult to develop a local approach which would be consistent with a draft Provincial policy when the policy was continuing to evolve. This made it difficult for the Committee to agree on a shoreline management strategy which would be acceptable to the municipalities and the shoreline community yet consistent with the Provincial requirements.

Shoreline Protection

Members of the Committee from the shoreline community advised that shoreline residents needed information and direction on appropriate ways to protect their properties from erosion and storm damages. In addition, there was a lack of understanding by landowners of natural shoreline processes and how these processes were affecting their properties and protection works. Finally, there was great confusion over legislation governing shoreline construction, the agencies enforcing this legislation and the regulatory approval processes in place. Conservation Authority staff and the coastal engineer recognized that there was already a great deal of generalized information available for the Great Lakes shorelines. However, much of the discussion and several of the protection methods outlined in these materials were not appropriate for the shoreline conditions within the study area. Therefore, it was decided that a supporting document to the SMP would be produced with a focus on the study area shoreline. The document would discuss the types of protection works being used and provide an evaluation of the effectiveness of these works. In addition, the document would provide landowners with an understanding of the protection works design process, introduce the range of available management alternatives and provide information to assist landowners in dealing with engineering consultants and contractors.

6.1 Public Meetings

On September 2, 1992, the Conservation Authority arranged a public meeting in an open house format at the Camlachie Community Centre for the residents of Plympton Township. The meeting was held to introduce the shoreline community to the shoreline management planning process and update them on proposed landuse and development policies. A newsletter and open house notice was prepared and mailed to each landowner adjacent Lake Huron in the City of Sarnia and the Township of Plympton. The meeting was attended by approximately 100 people and a summary of comments received by the Conservation Authority following the meeting can be found in Appendix C.

It was anticipated that the proposed landuse policies to address development adjacent the shoreline would be the most controversial aspect of the SMP. As such, the meeting was held to receive public input on the Shoreline Development Policy (draft September 1992) of the SMP. This development policy was based on the shoreline policies of the Ministry of Natural Resources. However, the MNR policy was not yet approved as a Provincial policy statement nor had it undergone a public review process. The landowners attending the meeting expressed a clear view that it would be more appropriate to await the adoption of a Provincial shoreline policy before proceeding to finalize local policies based on the Provincial position.

With the comments received from the public at the Open House and the continuing uncertainty on the content, approach and approval schedule of the Provincial policy, the Conservation Authority Board of Directors in November of 1992 requested that work on the SMP be suspended until such time as the Province adopted a Shoreline Policy Statement. As a result a corresponding meeting

was not held in 1992 for the Sarnia shoreline community.

On July 16, 1996, the Conservation Authority arranged a public meeting and open house at the Huron Oakes Recreation Centre for the residents of the City of Sarnia. The meeting was held to update the shoreline community on the approved Provincial Policy Statement and to provide an opportunity for residents of Sarnia to review and provide comments on the SMP (draft January 1996). The meeting was advertised in the local newspapers. In addition, the City of Sarnia undertook to mail the meeting notice to all of their landowners adjacent Lake Huron. The meeting was arranged with a presentation and question period followed by an opportunity for landowners to discuss individual properties and issues one-on-one with Conservation Authority staff. The meeting was attended by approximately 150 people. Comment sheets were provided with a request that written responses be forwarded to the Conservation Authority by August 16, 1996. A summary of comments can be found in Appendix C.

Following the Sarnia meeting, the Township of Plympton requested that the Conservation Authority organize an open house for Plympton residents. This meeting followed the same format as the Sarnia meeting and was held on August 22, 1996 at the Camlachie Community Centre. This second meeting was attended by approximately 100 people. Comment sheets were provided with a request that written responses be forwarded to the Conservation Authority by September 20, 1996. A summary of comments can be found in Appendix C.

Section 7 Glossary of Terms

Accepted Engineering Principles - those principles, methods and procedures involving wave uprush and other wave related hazards which are used and applied in current hydrotechnical engineering practice.

Accepted Geotechnical Principles - those principles, methods and procedures involving slope stability analysis which are used and applied in current geotechnical practice.

Accretion - the slow and imperceptible addition of shoreline by natural deposition.

Average Annual High Water Level - the average of the highest monthly mean level of each year over a period of time.

Average Annual Low Water Level - the average of the lowest monthly mean level of each year over a period of time.

Average Annual Water Level - the average of monthly mean water levels over the year.

Backfill - the material used to refill a ditch or other excavation, or the process of doing so.

Backrush - the lakeward return of water following the uprush of waves.

Backshore - the part of the shore or beach that is usually dry extending from the limit of wave uprush at the average annual high water level to either the place where there is marked change in material or physiographic form; or the line of permanent vegetation (usually the effective limit of storm waves); or the high water mark.

Bar - submerged or emerged embankment of sand, gravel, or other unconsolidated material built in the nearshore zone by waves and currents.

Bathometry - the topography of the lake bottom.

Beach - the zone of unconsolidated material that extends landward from the average annual low water level to either the place where there is marked change in material or physiographic form; the line of permanent vegetation (usually the effective limit of storm waves); or the high water mark. A beach includes foreshore and backshore.

Beach Nourishment - supplementing the naturally occurring supply of sand to the shoreline by importing suitable material from other sources.

Beach Starvation - the loss of beach building materials due to updrift changes in littoral transport conditions.

Bluff Toe - the intersection of the bluff with the beach (or the nearshore bottom, if underwater) as shown on the 1988 shoreline mapping.

Borehole Logs - a stratigraphic record, or "log" of the material which forms the subsurface obtained through drilling or boring a hole.

Breaking Point - the point at which a wave begins to break or deform.

Breakwater - a structure protecting a shore area, harbour anchorage, or basin from wave action.

By-passing of Sand - physically removing sand from one side of a structure (i.e. harbour structure) and placing it on the other side.

Celerity - velocity of a moving wave.

Closed Littoral Cell - a cell which does not receive or deposit littoral material from outside the cell limits.

Comprehensive Zoning By-law - a document adopted by a municipal council pursuant to the provisions of the *Planning Act* or the *Municipal Act* to control and direct the use and development of property within the boundaries of the municipality.

Control Points - related to land surveys; points of known or fixed locations regarding either horizontal and/or vertical distances.

Contour - a line drawn connecting points of the same elevation and used to represent topography or land surface.

Crown Land - all land (including land under water) held by the Province, both land which has never been sold and land which has been reacquired.

Current, Longshore - the current in the breaker zone moving essentially parallel to the shore generated by waves breaking at an angle to the shoreline and by the normal movement of water through the lake to its outlet.

D₅₀ - a measurement of sand grain size distribution.

Development - means the construction, erection or placing of a building or structure.

Dissipate - expend or scatter harmlessly, as of energy of moving waves.

Downdrift - the direction of the predominant movement of littoral materials.

Dune - ridges or mounds of loose, wind-blown material, usually sand.

Duration - in wave forecasting, the length of time the wind blows in the same or nearly the same direction over the fetch.

Environmentally Significant Areas - areas identified for their environmental value related to their hydrologic, biologic, or geomorphologic characteristics, as in wetlands, woodlots, or sites which possess rare and endangered species of flora and/or fauna.

Erosion - a volumetric reduction of shoreline by natural or human influenced processes.

Erosion Rate - the net loss of shoreline normally located above the lake surface elevation over a specific period of time.

Failure Plain (slip surface) - the plain or surface along which an unstable soil mass moves at failure; in bluff areas a curved line extending from the horizontal top of bluff a distance away from the crest and extending through the vertical face of the bluff usually in the vicinity of the toe of the bluff

Flora and Fauna - refers to the plant and animal species.

Fetch - the distance over water which waves are generated by a wind having a generally constant direction and speed.

Filet Beach - an accretional beach which exists due to the occurrence of an artificial structure (i.e. harbour structure) which interrupts the littoral drift.

Filter - a layer of well graded rock or a synthetic material between protection works and backfill soil to prevent escape of the soil through the voids in the protection works materials.

French Drain - a subsurface drainage inlet which is constructed by placing stone over a buried perforated drain pipe.

Gabion - an erosion control method using wire baskets filled with rock; commonly used for retaining walls and revetments.

Geodetic Referencing - describing a feature using known geographical coordinates (commonly using latitude/longitude or UTM grid coordinates).

G.S.C. - Geodetic Survey of Canada (G.S.C. = IGLD (1985)); datum for the referencing of elevation.

Geomorphic - based on the physical shape or landform which exists.

Groundwater - subsurface water occupying the zone of saturation. In a strict sense, the term is applied only to water below the water table.

Gully Erosion - the erosion process whereby water accumulates in narrow channels and, over short periods, removes the soil from this narrow area to considerable depth.

Groyne - a shore protection structure built at an angle from the shore to trap sediment drift and to protect the shoreline from erosion by currents and waves through the development of a beach.

Groyne Field - a series of groynes acting together to protect a section of shoreline.

Habitable Space - means rooms or spaces required and intended for overnight occupancy, and includes facilities for storage, heating, air conditioning, electrical, hot water supplies, plumbing, waste connections, etc. which are necessary to maintain the habitable condition.

Hazard Land - land which, because of its physical characteristics in combination with its location, presents a risk for its occupants including loss of life, property damage and social disruption.

High Water Mark - the upper most extent that water levels range, also associated with a break in slope or vegetation.

Historical Storm Event - a storm which due to its extreme magnitude of flooding and erosion hazard, is an event which is referred to for historical reference.

Hydrographic Survey - a survey of the lake bottom.

Ice Damage - damage related to the build-up and movement of ice along the shoreline during the winter and spring months.

Infilling - with regard to construction; development on previously undeveloped lots, generally bounded by existing development on both sides.

Infilling Severances - the division of land to create three (3) or less new building lots in existing developed areas generally bounded on both sides by existing dwellings.

I.G.L.D. - the International Great Lakes Datum (1985), referenced to mean water level at Father Point in the St. Lawrence River. Elevations referenced to the datum are dynamic elevations which take into account not only the measured linear height above the reference zero, but also the force of gravity at that particular locality. The resulting elevation differs by varying amounts depending on location from the standard orthometric elevation published by the Geodetic Survey of Canada; (IGLD 1985) = G.S.C.).

Inundation - the temporary submergence of shoreline normally located above lake level.

Jetty - an elongated artificial obstruction projecting into the lake from the shore to control shoaling and scour by deflection and dissipation of currents and waves.

Lag Deposits - residual accumulations of coarser soil particles (i.e. cobbles and boulders) from which the finer material has been carried away.

Lake Bank Overloading - creating a potentially unstable bank by adding additional weight to the upper area.

Lakeside Effects - the processes originating on the lake which act upon the shoreline and cause change (i.e. storm wave action, high lake levels).

Lakeward - the direction toward the lake when measuring distances over land.

Landside Effects - the processes originating on the land which act upon the shoreline and cause change (commonly related to human actions of drainage, construction and earth moving).

Landward - the direction toward the land when measuring distances over water.

Leeward - the direction toward which the wind is blowing, and the direction toward which waves are travelling.

Linear Development - development which exists in a linear alignment parallel to the shoreline, typically with each lot having shoreline frontage.

Littoral - pertaining to or along the shore, particularly to describe currents, deposits and drift.

Littoral Cell - areas under the continuous influence of specific longshore currents.

Littoral Sink - areas where the littoral materials are ultimately deposited and sand accumulates.

Littoral Transport - or littoral drift; the movement of littoral material in the littoral zone by currents, including movement parallel to the shoreline (longshore transport) and perpendicular to the shoreline (onshore/offshore transport); movement is due to the prevailing current and oblique wave direction.

Longshore - parallel to and near the shoreline, usually within the littoral zone.

Monthly Mean Lake Level - the average water level occurring during the month computed from the hourly readings in each month.

Moveable Dwelling - refers to design and site considerations which will allow a structure to be moved away from a hazardous area, and includes such factors as size of building in relation to the adjacent road systems, type of foundation, and available space for adjacent building relocation and space for moving equipment access.

Nearshore - an indefinite zone extending lakeward from the average annual water level to beyond the breaker zone defining the area of nearshore currents formed primarily by wave action.

Net Loss of Sand - the situation which results when inputs to the sediment budget are less than the losses to the budget resulting in a net loss.

New Dwelling - a building containing habitable space constructed on a previously undeveloped lot or replacing a dwelling on a previously developed lot.

Official Plan - a document adopted by a municipal council pursuant to the provisions of the *Planning Act* which identifies the existing use of land, guides and directs potential land uses, and establishes implementation policies within the boundaries of the municipality.

Offshore - the area extending lakeward of the breaker zone.

Offshore Breakwater - a structure located in the offshore area which is designed to protect a shoreline area, harbour, or basin through the dissipation of wave energy.

Onshore - the area extending landward of the normal high water mark.

Onshore Wind - a wind blowing toward the shoreline.

Outfall - a structure extending into a body of water for the purpose of discharging sewage or stormwater runoff.

Overtopping - passage of water over the top of a structure as a result of wave uprush and/or wind setup.

Pile - a long, heavy timber, or concrete or metal casing driven into the ground or lake bed to provide support or protection.

Post-glacial Lake - lakes formed as a result of the melting and retreat of the glaciers which formerly covered the Great Lakes basin.

Protection Works - refers to structural and/or non-structural works which are intended to address damages caused by flooding, erosion and other water related hazards.

Public Land - any land owned or administered by a public body or agency, including lands owned by Federal, Provincial and municipal governments and lands held by agencies such as parks commissions and conservation authorities.

Reach - portions of the shoreline containing similar physiographic or biological characteristics and shoreline dynamics, such as erosion rates, flood elevation; includes such characteristics as shoreline alignment and orientation, offshore bathymetry, fetch length, sediment transport rates, flood susceptibility, land use suitability and environmental features.

Recession - a landward retreat of the shoreline by shore processes.

Redevelopment - means the reconstruction or replacement of existing buildings or structures and can include major additions to existing buildings.

Remedial Works - structural measures intended to provide a remedy specifically aimed at problems of erosion and inundation for the purposes of shoreline protection.

Remnant Dune - a dune feature which has been stabilized by development practices such as protection works, vegetation and/or building construction.

Retaining Wall - wall designed to provide support to an adjacent feature or structure.

Revetment - a sloping facing of quarried stone, concrete or similar material constructed to protect an embankment or adjacent development against erosion and failure by wave action or currents. The sloping nature of the structure acts to disperse and dissipate wave energy as opposed to reflecting the energy.

Riparian Owner - the owner of land containing or directly abutting a natural lake or watercourse.

Riparian Rights - the rights of a person owning land containing or bordering on a watercourse or other body of water in or to its banks, bed or waters edge.

Riprap - quarried stone or clean broken concrete (generally 10-25 centimetres in diameter) used as backfill, filter material or facing layer in revetment, splash pad and scour pad construction.

Rubblemound Revetment - a sloping pile of randomly shaped and randomly placed riprap material covered with a facing layer of selected stones or engineered concrete units arranged and fitted together.

Sand - granular soil or detritus coarser than silt and finer than gravel, and ranging in diameter from 0.06 to 3.0 millimetres.

Scour - removal of material by waves and currents, especially at the toe of shoreline protection works or bluff features.

Scour Pad - a facing of quarried stone or broken concrete constructed at the base of protection works to dissipate wave energy and prevent the erosion of supporting materials.

Seawall - a structure separating land and water areas primarily designed to prevent erosion and other damage due to wave action.

Sediment Budget - gives an estimate of material entering the littoral zone from each source and the amount of sediment deposited at each sink or barrier along the shore. The sediment budget must balance; that is, the total amount of supply must equal the total amount deposited plus the amount still in transport.

Sediment Source Area - that area of the sediment budget which contributes a large quantity of material to the overall budget.

Seepage - water escaping through or emerging along an extensive line or surface; the slow movement of water through soil by gravity.

Seiche - an oscillatory motion resulting in alternate high and low water levels at each end of a lake that continues after the originating force has ceased.

Setback Requirement - a distance measured inland from an edge of a feature such as a bluff, where construction is prohibited.

Severances and Subdivisions - refers to the assemblance and division of land in previously undeveloped areas or to create more than three (3) building lots.

Sheet Pile - a pile with a generally slender flat cross section to be driven into the ground or lakebed and linked or interlocked with like members to form a vertical wall or bulkhead.

Shoals - off shore areas which have lesser depths of water than surrounding depths.

Shoreline - the area of interface between land and water extending from the lakeward limit of the littoral zone landward to the first major change in terrain.

Silt - inorganic particles carried in suspension or deposited by currents, ranging in diameter from 0.05 to 0.005 millimetres.

Slump - a failure of a bluff slope with a mass movement of soil along a failure plain.

Spit - a point of land or a narrow shoal projecting into a body of water from the shore.

Splash Pad - a facing of quarried stone, broken concrete or other stable material constructed above the crest of protection works to absorb and dissipate the energy of overtopping water following wave impact or uprush.

Stable Slope - refers to the angle a slope would achieve when toe erosion is absent.

Stillwater Level - the elevation a water surface would assume if all wave action were absent.

Stratigraphy - is the description of the rock layers or units of a physical feature (also known as lithographic units) commonly determined by borehole analysis.

Tableland - that area above the bluff or bank slope which is relatively flat.

Threshold Slope Inclination - the slope angle which, if exceeded, will result in an unstable condition. It is determined by the inherent strength of the material which comprises the slope.

Till - unsorted, unlayered consolidated glacial debris which commonly forms the bluffs along the southern Great Lakes.

Toe Erosion - the erosion which occurs at the bottom of bluffs largely as a result of the continuous removal of earthen material by waves and currents.

Topography - the configuration of a surface including its relief, the position of its streams, roads, buildings and other physical features.

Undercut - undermining, erosion of the lower part of a steep bank so as to reduce the stability of the upper part.

Updrift - the direction opposite that of the predominant movement of littoral materials.

Wave - a ridge, deformation, or undulation of the surface of the water.

Wave Crest - the highest part of the wave.

Wave Diffraction - the restructuring and redirecting of waves by underwater structures or features.

Wave Direction - the direction from which a wave approaches.

Wave Height - the vertical distance between a wave crest and the preceding wave trough.

Wave Hindcasting - the use of historic synoptic wind charts to calculate wave characteristics that probably occurred in the past.

Wavelength - the horizontal distance between similar points on two successive waves measured perpendicular to the wave crest.

Wave Period - the time for two successive wave crests to pass a fixed point.

Wave Reflection - the return of a portion of a wave lakeward following uprush or breaking on a steep beach, barrier or other reflecting surface.

Wave Trough - the lowest part of a wave between successive wave crests.

Wave Uprush - or wave runup; the rush of water up onto the beach or shore following the breaking of a wave; for any given water level the limit of uprush is the point of farthest uprush.

Wind Setup - the vertical rise above normal water level on the leeward side of a body of water caused by wind stresses on the surface of the water.

Windward - the direction from which the wind is blowing.

Section 8 References

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Section 9 Summary of Supporting Documents

9.0 Lake Huron Shoreline Processes Study (1989)

The Lake Huron Shoreline Processes Study is an unpublished report prepared for the four (4) conservation authorities with jurisdiction along the Ontario shoreline of Lake Huron including the Saugeen Valley, Maitland Valley, Ausable Bayfield and St. Clair Region Conservation Authorities. In order to take into account the regional nature of shoreline processes in the development of shoreline management plans, the Conservation Authorities determined that a detailed description of the natural shoreline processes was required before comprehensive shoreline planning could proceed. The coastal engineering firm of F.J. Reinders and Associates Canada Limited was retained to conduct a detailed examination of the shoreline processes and to provide a report that would support the development of effective shoreline management plans and which would assist conservation authority staff in managing the shoreline.

The report addresses a 180 kilometre length of the Ontario shoreline of Lake Huron, extending from McRae Point to Sarnia. The report provides information on the study area shoreline, including: the definition of littoral cells and reaches within those littoral cells; the description of these reaches with regards to composition, erosion, and sand transport; quantification of the amount of sand moving alongshore; and, recommendations concerning the future management and development of the shoreline. A detailed description of the shoreline processes acting along the shoreline is provided, along with the implication of these processes for shoreline management. Such processes include sand supply, sand transport, bluff recession and erosion. A discussion of existing shore protection and its effects on the shoreline and shoreline processes is also presented. A detailed discussion of the glacial and post-glacial history of the area is presented and provides a good summary of those characteristics of the shoreline that exert a control on the present day geomorphic processes.

9.1 Lake Huron Shoreline Erosion Hazard Delineation Study (1991)

The Lake Huron Shoreline Erosion Hazard Delineation Study is an unpublished report prepared by F.J. Reinders and Associates Canada Limited and Geomatics International Incorporated in 1990 for the St. Clair Region Conservation Authority. In order to develop and evaluate management alternatives for the study area shoreline, there was a need to understand how the shoreline had historically responded to the natural shoreline processes and human influences such as protection works. Shoreline response is often reflected in the erosion and recession rates. As erosion is an ongoing process along the shorelines of the Great Lakes, effective erosion hazard management requires continued monitoring of the shoreline and the ability to predict long term erosion rates.

The report documents the use of an Ontario Land Survey completed in 1934 and shoreline mapping completed in 1990 under the Canada/Ontario Flood Damage Reduction Program to compare the positions of shoreline features over a 54 year period. This comparison was refined using information collected under the Canada/Ontario Great Lakes Shore Damage Survey and the Great Lakes Erosion Monitoring Program. Using the comparison, the consultant was able to determine historical bluff recession and accretion rates which could then be used to predict future shoreline change. The resultant erosion rates were used to delineate regulatory shoreline development setbacks based on shoreline policies of the Ontario Ministry of Natural Resources.

The report was revised and updated in 1992 based on recommendations from W.F. Baird & Associates in their memorandum dated October 31, 1991 and subsequent re-interpretation of top of bluff locations from the FDRP Shoreline Mapping.

9.2 Design Considerations for Shore Protection Structures (1992)

The purpose of the document is to present an overview of design considerations for shoreline protection works in the study area, recognizing the presence and performance of existing structures, as well as impacts of existing and new protection works on the shoreline processes. The report recognizes that information on shoreline erosion and protection works alternatives for the Great Lakes shorelines was widely available from several sources including the Ontario Ministry of Natural Resources, Environment Canada and the United States Army Corp of Engineers. The discussion refers to this information where it has direct application along the shoreline within the study area. The report emphasizes that the information provided is general in nature and intended for guidance purposes only. It is recommended that a qualified professional engineer with experience in Great Lakes shoreline processes, be retained to design protection works for any specific site.

Appendix A

Municipal Planning Documents
Shoreline Policy Excerpts

Appendix B

Shoreline Management Advisory Committee
Meeting Minutes and Written Comments

Appendix C

Public Meetings
Written Responses